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Phylogenetic studies on the blood-inhabiting trematodes

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PHYLOGENETIC STUDIES ON THE BLOOD-INHABITING TREMATODES

By
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Alden E. Noble

who inspired and
directed the writer
this thesis is affectionately
dedicated

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INTRODUCTION

Trematodes belonging to the blood-inhabiting group have long attracted the attention of parasitologists and medical men, especially those trematodes belonging to the family Schistosomidae because three widely distributed species, Schistosoma japonicum, S. haematobium, and S. mansoni, are parasitic in man, and in endemic regions are the cause of important human diseases. These schistosomes, with a few exceptions, have undergone more detailed research than any other trematodes.

Since the discovery of the first digenetic trematode exhibiting sexual dimorphism by Rudolphi (1819), which was named Distoma canaliculatum, and the descriptions of the other blood flukes up until the present time, a vast amount of material has been put forth in publications having a more or less limited circulation. The writer has, therefore, attempted to assemble descriptions of all the genera and species, hoping that this will be an aid in the identification of these trematodes. Unfortunately many of the descriptions are inadequate as they are based in many instances upon a limited number of specimens.

In compiling these data the writer was struck by the possibility of further using them to investigate the genetic

and evolutionary relationships of the blood-inhabiting trematodes. It was found necessary to collect and examine the research publications of previous workers in this field. Rather than place all this work in one volume, which would be a thesis in itself, the writer felt that a short historical summary would be adequate as an introduction.

Looss (1899) noticed a similarity in the structure of the suckers, the dermo-muscular sac, and in the details of the digestive tract in those blood flukes that had been found. He concluded that their adaptations to existence ~~were~~ similar, ~~having~~ as he had a constant environment and a common food supply.

Odhner, (1912) through a long study, concluded that the blood flukes were genetically related.

The discovery of the life cycles of Sanguinicola and Schistosoma japonicum added further evidence in support of this hypothesis.

Stunkard (1920) said that the group of blood-inhabiting trematodes contained distomes, monostomes, and sucker-less forms. He worked on the theory that they were all related, and through this work and the work of others in other trematode fields it has been found that the adhesive

organs are somewhat variable within a given species. Another point that had caused considerable confusion was the absence of the acetabulum in various species. This, as inferred by Stunkard and subsequently demonstrated, is due to the gradual diminution and loss of the organ. He erected a new family, Harmostomidae, with two sub-families, Harmostominae and Liolopinae. Liolopinae contains the genera Liolope Cohn (1902), Heliocotrema Stunkard (1920), and Hapalotrema Looss (1899). He regarded Hapalotrema as the significant and connecting form in this species, the Bilharzia type coming from Hapalotrema.

Ward (1921), noted marked differences in the digestive, excretory, and reproductive systems. He maintained that Hapalotrema was misplaced. He erected a new family containing Hapalotrema Looss (1899), Spirorchis MacCallum (1918), and Proparorchis n.g. He regarded the blood flukes of turtles as being related to the Schistosomatidae and closely related to Aporocotyle and Sanguinicola.

Stunkard (1921) pointed out the synonymy of Spirorchinae and Hapalotreminae.

Much of the evidence for a monophylogenetic origin and genetic relation has been presented by Odhner and Ward. Odhner (1911) proved the similarity of Sanguinicola and

Aporocotyle and in 1912 included them in the family Aporcotilidae. Ward (1921) placed Spirorochis and Hapalotrema in the same family and validated Schistosoma unity. This came about through the work of Odhner (1912) in demonstrating the similarity between Hapalotrema and Schistosoma and that of Ward (1921) in demonstrating the similarity of Spirorchis and Schistosoma.

Stunkard (1923(demonstrated the relationship of the Spirorchidae and Aporocotilidae.

Another problem is that of the dioecious condition in the Schistosomes. It is beyond the scope of this thesis to go into great detail upon this problem, although discussion of what is known concerning this problem will occur later in this paper.

PART I

SYNOPSIS OF THE FAMILY APOROCOTILIDAE

The highly interesting genera of blood flukes Aporocotyle, Sanguinicola, Deontacylix, and Paradeontacylix are unique among the digenetic trematodes in having lost both the suckers. They have long been of great interest to helminthologists through their relationship with the other families of blood flukes. There have been attempts by some helminthologists, without too much success, to find the genera or species from which the blood flukes of fishes ~~has~~ have been derived. Since the writer is interested primarily in demonstrating the relationships between the families of blood flukes, the derivation of the blood flukes from a specific group of trematodes will not be ~~entered into.~~ discussed. In passing, though, it is of interest to note that Mehra (1934) constructed a tree giving his interpretation of the probable phylogeny of the blood flukes, in which he derived the blood flukes from the family Liolopinae through the genus Liolope.

As a result of the study of the family Aporocotilidae it became apparent that a synopsis of the family would be of great aid to future workers in this field. The writer has, therefore, attempted to compile descriptions of all the genera and species, placing them in one volume.

Family APOROCOTILIDAE Odhner, 1900

Family diagnosis.- Small to medium sized hermaphroditic blood-inhabiting flukes with weakly developed musculature and no suckers. Body armed with spines and cilia and sometimes both. Pharynx absent in all but one species. Esophagus long, surrounded by gland cells particularly prominent at the posterior end. Nerve ganglia and commissure with nerve stems prominent. Ceca variable, the gut being of the basic H-shaped type. Testes divided into a large number of follicles. Ovary usually found in testicular field between anterior and posterior testicular mass. Seminal receptaculum and Laurer's canal usually present. Vitellaria follicular, mainly along line of intestinal ceca, but may spread across body in front of and behind genital field. Ova usually large, spherical to three-cornered, may or may not possess polar filaments. Miracidia with pigmented eyespots. Cercaria of characteristic furcocerariae type. Parasitic in the blood system of fish.

Genus SANGUINICOLA Plehn, 1905

Generic diagnosis.- Aporocotilidae; Body is very contractile, lancet-formed, more or less armed. Anterior end has a trunk, without suckers. Acetabulum reduced, situated in the middle of the body, consisting of a pharynx, a long esophagus, a shortened intestinal lobe, and a subterminal oral opening with a toothed appearance. The esophagus forms on joining the gut a bulbous swelling or secretion reservoir. The excretory system consists of two long, parallel stems which posteriorly form a V-shped bladder opening out in the excretory pore; few flame cells. The nervous system consists of two cerebral ganglia at the sides which are united in the pharynx region by a cross commissure; from the cerebral ganglia there go one or more stems anteriorly and posteriorly. Genital pores located on the dorsal side of the body. Testes in mid-body region in the form of little bubbles on the right and left forming a semen ladder. This ladder becomes more or less sinuous as it going posteriorly and at the end passes over into a cirrus which ends in a group of cells. A cirrus pouch and prostrate lacking. Independent seminal vesicle is lacking. The ovary consists of two symetrical halves the commissure of which lies behind the testes and in front of the pos-

terior genital pore. The wings of the ovary posteriorly embrace the region of the testes. The oviduct originates from the ovary going posteriorly where it unites with the vitelline duct. The unpaired vitelline duct is located ventrally in the median line going for a long distance from the anterior end to the posterior end. From the fusion of the oviduct and the vitelline duct there results a duct which passes over anteriorly into a widened front oötype. The female genital pore is in the neighborhood of the male genital pore situated somewhat in front of it. Its diameter is greater than that of the cirrus. The seminal receptaculum, as well as Laurer's canal, and a uterus, is lacking.

There is only one egg formed at a time, which is immediately thrust to the outside. The egg is of the very characteristic three-cornered form lacking an operculum as well as seams. It grows and matures in the blood of the host and has dimensions which are characteristic for every species.

The miracidia leaves the egg shell in the host; has dimensions which are constant for every species. The body is covered in its entirety with equal length cilia, and is provided with a pigmented eye, a pair of frontal glands, as well as a boring apparatus. The excretory system consists of a pair of flame cells in the middle of the body from which arise excretory vessels which have their pore in the posterior end of the body. The rear body region is occupied by germ balls. The miracidia penetrates into the snail where it develops sporocysts. The sporocysts are oval to sack-shaped to thread-shaped. The sporocysts contain fork-tailed cercaria having bodies with a strong undulating membrane. The tail is long, forked at the end, each end provided with terminal plates each bordered by narrow little films. Suckers and actual pharynx lacking. Anterior end of the body with a retractile trunk. The body and tail with a delicately ridged cuticle; this is covered on body and tail with hairs or bristles. Paired frontal glands on both sides of the intestinal canal. Two excretory vessels which laterally form in the posterior end of the body a bladder from which an unpaired stem goes to the tail, where again a forking into two stems occurs, ~~which~~ these stems open at the base of two end plates.

Parasitic in the blood system of fishes being specific for host.

SANGUINICOLA INTERMEDIA Ejsmont, 1926

Specific diagnosis.- Sanguinicola: Size never reaches 1 mm.; entire body with exception of trunk and posterior end covered with spines; whole body covered with minute cilia. This form distinguishes itself through delicacy and lacks sharp contour of the individual organs. The intestinal sac consists of from four to five lobes; in the latter case the lobe formed in a secondary manner can be determined as such. Nerve stems split in two. Excretory bladder strong. About 10 pairs of testes. Vas deferens in its course posteriorly has a stretched appearance, is not as sinuous as in other Sanguinicola species. Mature egg as well as miracidia are the smallest in the species. Egg measures 42 to 59 u by 30 to 35 u. Egg not noticeably lengthened in direction of longer axis of miracidium and approaches the appearance of an equilateral triangle. Dorsal continuation of egg much longer than in other species. Miracidia measure 38 by 15.5 u. Sporocyst and cercaria unknown.

Hosts.- Primary, fish (Carassius carassius naturally and Carassius carassius auratus experimentally; secondary unknown.

Location.- Blood system.

Distribution.- Europe (Warsaw).

SANGUINICOLA INERMIS Plehn, 1905

Specific diagnosis.- Sanguinicola: Maximum size 1 mm.; body without spines; arming on cuticle consists of tiny rods or bristles. The intestinal sac consists of four diverticula. The strong nerve stems are uniform lengthwise, without a trace of splitting. Excretory bladder weakly developed, slightly swollen juncture of the end parts of the two excretory vessels. Testes number 15 pair. Vas deferens in its course posteriorly is sinuous, making three to four turns. Mature eggs measuring 61 to 70 u by 29 u contain miracidia. The egg is markedly lengthened in the direction of the longer axis of the miracidium. Dorsal continuation of the egg short. Miracicium with a well developed cone-shaped trunk which is shoved out far forward. Measures 42 by 19 u. Sporocysts roundish to blunt,

measuring .19 to .30 mm. by .30 to .47 mm. Furcocercous type of cercaria measuring 87 to 120 u in body length, 15 to 25 u in body breadth, 209 to 285 u in the length of the tail, and 45 to 98 u in the length of the fork. The forking of the tail shows no distinct separation from the stem. The membrane goes from the fork to the stem.

Hosts.- Primary, fish (Cyprinus carpio); secondary, snails (Limnea stagnalis (L.), L. ovata, (Drap.), L. auricularia (L.), L. palustris (Mull.), Bithynia leachi (Shepp.), Planorbis corneus (L.), P. planorbis (L.), Vivipara fasciata (Mull.).

Location.- Blood system.

Distribution.- Baltic Sea.

SANGUINICOLA ARMATA Plehn, 1905

Specific diagnosis.- Sanguinicola: 1.5 mm. long; armed with strongly developed marginal spines; cilia lacking. Individual organs clearly outlined. The intestinal sac consists of five lobes of equal size. It was impossible to determine which lobe formed in a secondary manner. The nerve stem split into two and rarely three stems. The excretory bladder strongly and typically developed. About 15 pairs of testes. The vas deferens goes posteriorly resembling S. intermedia in its course. Eggs measure 59 to 74 u by 40 to 44 u. Miracidia measure 48.5 u by 21 u. The sporocysts and cercariiae have not as yet been determined with any certainty.

Hosts.- Primary, Fish (Tinca tinca); secondary, snails (Limnea stagnalis (L.), L. ovata (Drap.), L. auricularia (L.), L. palustris (Mull.), Bithynia leachi (Shepp.), Planorbis corneus (L.), P. planorbis (L.), Vivipara fasciata (Mull.).

Location.- Blood system.

Distribution.- Europe (Sweden and Germany).

SANGUINICOLA VOLGENSIS Rasin, 1929

Synonym.- Janickia volgensis Rasin, 1929.

Specific diagnosis.- Sanguinicola: Maximum size 2 mm. Trunk comparatively small. Body edges, with the exception of the trunk and the posterior end of the body, have the appearance of the teeth of a saw. Starting from the genital pore are bristles on the tips of the teeth marginally. There are in the whole some 100 of these bristles which are up to .038 mm. long. The intestine is four-lobed. There

are two long nerve stems in each half of the body. There are over 20 pairs of testes, which are frequently forked. The testicular field at the height of the rear ovary forms an S-shaped loop, there the end part, which is common to the oviduct and the passage of eggs, is very short. In the metraterm are 1-9 complete eggs measuring about .017 by .013 mm. Fully developed eggs found in the gills of the host contain miracidia which measure .048 by .038 mm the space between the strong outer covering and the inner covering being filled with fine little grains. Sporocysts and cercaria are unknown.

Hosts.- Primary, fish (Pelicus cultratus and Alburnus alburnus); secondary, unknown.

Location.- Blood vascular system.

Distribution.- Baltic Sea.

SANGUINICOLA CHALMERSI (Odhner, 1924) McIntosh, 1934

Specific diagnosis.- Sanguinicola: 647.4 to 1,228 .4u in length. A groove similar to that of male Schistosomes is shallow over the greater length of the body, deep posteriorly, and terminating just anteriorly to the hind end of the body. This furrow or groove is formed by the inturning of and posterior fusion of the edges of the body and is apparently a permanent formation, judging by the posterior pocket. The edges of the body that border this furrow contain spinelets. The spinelets are distinct rods and are almost entirely embedded in the subcuticula and parenchyma save for their outer extremities, which project slightly. These spinelets attain a maximum length of about 27u. The gut is in a much reduced condition as compared with the gut in most Turbellaria and Trematoda; but that it is a gut and not a "frontal gland" is shown not only by the presence of a well-marked muscular sucking pharynx and by the non-glandular character of the wall of the gut-sac, but also by the occasional presence of blood corpuscles in its lumen. The anterior mouth-opening is extremely minute, leading to a short, very narrow, though distensible channel opening into the thick-walled (when empty) elongated pharynx which extends posteriorly as far as the transverse nerve-commissure. This pharynx is capable of great distension. Its wall when not distended is of considerable breadth and is transversely striated. From the posterior end of the pharynx to the gut sac is a narrow esophagus, with a wall much thinner than that of the pharynx and covered externally with a layer of nu-
cleated cytoplasm. The esophagus apparently lies ventral

to the nerve commissure. The gut sac, situated at the hind end of the anterior third of the body, is somewhat irregular in shape but is more or less compact (according to Odhner). Plehn says it is broken up into four of five distinct lobes. Its wall consists of a thin, occasionally nucleated, layer of glandular cytoplasm.

The genital pores are dorsally located. The male pore is situated on the left, the female pore on the right. The female genital glands consist of an ovary situated immediately behind the testes, and of vitellaria occupying the sides of the body. The ovarium forms two symmetrical, more or less aciniform wings which, in their whole extent, are placed behind the testicular field. The vitellaria extend on both sides from a point not far from the anterior end to the level of the anterior border of the cirrus pouch, overreaching the ovary backwards. There are two different female ducts running closely parallel in the hindmost part of the body, and uniting to a short common duct which enters the bulbous structure which Woodland (1924) calls a "distinct spherical fertilization chamber on its posterior aspect". From the anterior side of the fertilization chamber arises the vagina, which is short, narrow at first, and wider after, and opens on the ventral surface by a circular vaginal pore which lies at the end and at the bottom of an elongated ridged muscular oval groove, directed to the left and posteriorly, the vaginal groove. The main vitelline duct runs in the median line of the testicular field close to the ventral surface, receiving long transverse secondary ducts from both sides; the main duct takes its origin at the hind margin of the gut-sac; in its continuation backwards the duct crosses both the ovary and the oviduct ventrally, and can be followed by its contents all the way to the distal end of the oviduct, where the union of both ducts takes place.

The testes are bounded anteriorly by the gut-sac, and laterally and posteriorly by the ovaries. They consist of large ovoid or spherical capsules connected with the main vas deferens in the median line by transverse ducts. The main vas deferens lies ventral to the oviduct. Immediately posterior to the ovaries the vas deferens lies below the oviduct, but turning to the right it passes over the dilated oviduct, then, becoming considerably dilated bends sharply left, and then as sharply again it bends to the right where it is surrounded by a cucumber-shaped cirrus pouch. Eggs unknown.

Hosts.- Primary, fish (Auchenoglansis occidentalis, Synodontis schall); secondary, unknown.

Location.- Blood in heart.

Distribution.- Sudan.

Genus APOROCOTYLE Odhner, 1900

Generic diagnosis.- Aporocotilidae: Characters of the single species Aporocotyle simplex.

APOROCOTYLE SIMPLEX Odhner, 1900

Specific diagnosis.- Aporocotyle: Body strongly flat with fairly parallel sides. The anterior end, depending upon the amount of the contraction of the worm, runs from blunt to sharp. Posterior end rounded. Length 3.5 to 5 mm.; breadth .45 to .75 mm. The last quarter of the body is always a little narrower than the front quarters. The thickness varies from .10 to .15 mm. Suckers and other adhesive organs absent. Cuticle is covered with fine spines which form little groups, especially on the ventral side at the anterior end. Length .006 mm. These spines are probably the only fastening appendages of the worm.

The mouth opening is at the anterior end a little to the ventral side and leads into a 1 mm. long esophagus which extends posteriorly in the median line of the body. Pharynx absent. The esophagus forks into two ceca which run to the rear parallel with the edges of the body and end blindly. At the juncture there originates a large unbranched blind sac which extends anteriorly and the length of which amounts to 1/2 to 2/3 rds of the esophagus. The actual gut is, therefore, H-shaped. The course of the gut depends upon the amount of food it has ingested.

The excretory system opens at the posterior end through an excretory pore, shifted a little dorsally, which leads into a short unpaired part. The latter part soon forks into two stems which run to the anterior under the ceca.

The nervous system consists of two brain ganglia and commissure, as well as nerves running anteriorly and posteriorly.

There are 130 testes irregularly rounded which fill a rectangular field between the juncture of the ceca and the sides of the ceca, the rear edge of which is 1 mm. from the posterior end of the body. Vasa efferentia of the testicular bladder goes posteriorly and forms an unpaired seminal bladder which at the medial posterior edge of the testicular field enters a cirrus pouch which surrounds the male genital pore. The cirrus pouch contains a weak semen bladder and an ejaculatory duct which describes a curve to the left, becoming concave. The ejaculatory duct has its opening with the female passage in the dorsal genital pore situated on the inner side of the left cecal branch.

The ovary is somewhat circular or irregularly oval and is located on the right side between the posterior testis and the end of the body, the right edge lying close to the right ceca. The average diameter is .18 mm. From the posterior edge of the ovary originates the oviduct, which goes obliquely to the rear and the interior, and when it reaches the medial line it receives the unpaired vitelline duct. The part following this is a spindle-shaped oötype which extends obliquely to the anterior and the right side and passes over to the posterior edge of the ovary into the uterus, the front part of which is the seminis receptaculum uterinum. The uterine windings fill the space between the ovary and cirrus pouch, go to the right side of the body, take the field between the cirrus and the ceca, and pass over into the end portion of the vagina, which, along the rear edge of the testicular field, goes back to the left and enters the dorsal genital pore.

One completely shelled egg was found measuring .135 by .033 mm., the contents of which were an unsegmented germ cell embedded in a mass of dilapitated yolk cells. The windings of the uterus are filled with a mixture of germ and yolk cells without a sign of a shell.

Cercaria unknown or unrecognized.

Hosts.- Primary, fish (Pleuronectes flesus and P. limanda); secondary, unknown.

Location.- Circulatory system.

Distribution.- Europe (Sweden).

Genus PARADEONTACYLIX McIntosh, 1934

Generic diagnosis.- Aporocotylidae: Small slender trematodes; cuticle on ventral surface of lateral margins armed with transverse rows of spines; lateral margins of body thin and recurved ventrally for a part of their length, forming parallel folds about one-sixth as wide as the body. Suckers absent; pharynx absent; esophagus long; intestine H-shaped. Testes numerous, arranged in two median, irregular longitudinal rows, extending from fork of crura to ovary. Ovary median, in posterior third of body. Uterus long, with few coils, postovarial. Genital pores separate, dorsal, postovarial; male pore posterior and lateral to female pore. Vitellaria extensive; unpaired median vitelline duct extending from zone of ovary to oötype. In circulatory system of marine fishes.

PARADEONTACYLIX SANGUINICOLOIDES McIntosh, 1934

Specific diagnosis.- Paradeontacylix: Body slender, 325 mm. long by 330 u wide; cuticle on ventral surface along margin of body provided with numerous rows of spines; twelve of the spines at posterior end of body comparatively large and conspicuous, rose-thorn-shaped, arranged in rows of three spines each, the largest about 15 u long by 9 u wide at base; spines along margin of body arranged in approximately 500 transverse rows, the number of spines per row increasing from three per row at posterior end to fourteen per row at equator of body. Suckers absent; mouth opening subterminal. Esophagus 371 u long by approximately 30 u wide. Anterior portion of esophagus drawn out into a narrow tubular structure having its posterior end slightly dilated, but apparently not forming a true pharynx. Intestine with four indistinct diverticula, two extending anteriorly and two posteriorly, longest measuring approximately 147 u. Testes ovoid, approximately 60 in number, averaging about 60 u long by 90 u wide, arranged in two irregular rows between fork of crura and ovarian zone; zone of testes 1,342 mm. long, field 185 u wide. Vas deferens well developed, apparently serving as seminal vesicle, leading from testes to male genital pore; cirrus not observed; male genital pore dorsal, 457 u from posterior end about 61 u from left margin of body. Ovary somewhat shield-shaped, 213 u long by 244 u wide, with lobed or fissured margins. Oviduct 457 u long, originating from apex of shield, and leading to oötype; posterior half of oviduct dilated, serving as a seminal receptacle. Vitellaria extensive, occupying most of available space from near anterior end of body to ovarian zone; vitelline duct well developed, median, extending between oviduct and uterus, from ovarian zone to oötype. Two indistinct lobes, lateral to testes, apparently the paired vitelline ducts, observed, but not traceable posteriorly to union with unpaired median duct. Oötype 45 u by 30 u, 397 u from posterior end of body; Laurer's canal not observed. Uterus posterior to ovary, extending from oötype posteriorly about 120 u, then anteriorly as far as ovary, making a few coils, and then descending to female genital pore; proximal portion of uterus filled with spermatozoa; terminal portion dilated, containing several eggs. Female genital pore dorsal, 152 u anteromesal of male genital pore. Eggs oval, 17.8 u by 11.5 u, with thin colorless shells.

Hosts.- Primary, fish (Seriola lalandi); secondary, unknown.

Location.- Blood vessels of gills.

Distribution.- Atlantic Ocean, Miami, Florida.

PARADEONTACYLIX ODHNERI Layman, 1930

Synonym.- Aporocotyle odhneri Layman, 1930.

Specific diagnosis.- Paradeontacylix: Elongated, narrow toward ends. Length 9.8 mm., breadth 1 mm. Cuticle covered with spines in diagonal rows. Mouth located at anterior end of body on a small protrubance. Suckers absent. Esophagus narrow, 1.32 mm. long. Intestine consists of four blind ceca, of which two short ones extend to the anterior end and two long ones extend to the posterior end. Length of anterior ceca .36 to .45 mm.; length of posterior ceca 4.917 to 5.177 mm.

Ovary situated far in front of genital pore, consists of ball-shaped lobes. Length .344 mm., breadth .59 mm. Numerous testes which lie medially and posteriorly almost reaching the ovary. Vitellaria extend on both sides of the body almost to the anterior end; toward the rear they end behind the ovary. In front of the ovary the vitellaria come together. The uterus, which goes in a posterior direction, is located in the space behind the ovary and the genital pore. Eggs oval; length .035 to .040 mm., breadth .021 to .024 mm. Cirrus pouch pea-shaped; length .180 mm., width .065 mm. Excretory system consists of two trunks which combine anteriorly in an anastomase and posteriorly fuse into one trunk.

Host.- Primary, fish (Spheroides borealis); secondary, unknown.

Location.- Mesenteric circulatory system.

Distribution.- Sea of Japan.

Genus DEONTACYLIX Linton, 1910

Generic diagnosis: Aporocotilidae: Body long-oval, flattened, tapering gradually to anterior end and abruptly to posterior end, 2.24 mm. to 4 mm. in length by 0.77 mm. in width. Mouth minute anteriorly, ventrally located. Body covered dorsally and laterally with minute, rod-like spines. No distinct oral sucker; no pharynx; and no ventral or other sucker present. Narrow esophagus divides about anterior third of body. Two branches divide into two smaller branches. Genital openings close together, dorsal side near posterior end. Short tube leads from aperture to folded, tubular uterus. Cirrus short, leads from its opening to seminal vesicle. Vas deferens between uterus and ovary. Seminal receptacle in front of seminal vesicle. Ovary in front of seminal receptacle to the right. Ovary small, deeply lobed. Vitelline glands fill greater part of

anterior half of middle region of body. Testes are diffuse organs lying ventrally in front of folds of uterus.

DEONTACYLIX OVALIS Linton, 1910

Specific diagnosis.- Deontacylix: 2.24 to 4 mm. long by 0.77 mm. wide. Body long-oval, flattened, tapering gradually to the anterior end and more abruptly to the posterior end. General color white, the branches of the intestine yellow. The mouth is minute on the ventral side very close to the anterior end. The body is covered dorsally and laterally with minute, short, slender, rod-like spines in transverse rows, the rows about 0.009 mm. apart. There is no distinct oral sucker, no pharynx, and no ventral or other sucker present. The moderately narrow esophagus pursues a somewhat sinuous course to about the anterior third of the body, where it divides into two branches. These branches soon divide into two smaller branches, one extending forward and the other back. These secondary branches are somewhat irregular in outline, being short-sinuate or sacculate with one or more additional branches. The posterior rami reach to about the middle of the length of the body. Along the margin of the body there is a distinct border, finely granular and more lightly staining than the interior, and separated from the interior region by a light line having the appearance of a nerve. That is, two lateral nerves can be traced from a short distance behind the mouth, where they form a common band which crosses the esophagus dorsally and sends branches forward to unite again around the mouth, back to near the posterior end of the body.

The genital openings are close together and close to the posterior end of the dorsal side. A short tube leads from its aperture, a little to the left of the median line, to a closely folded, tubular organ which appears to be the uterus. It is crowded with small ova, 0.022 mm. by 0.013 mm. The ova are ovate, oval-elliptical, and pyriform, and they appear to be thin shelled. When highly magnified each ovum is seen to contain several coarse, granular masses of yolk. The cirrus is short and leads from its opening near the opening of the metraterm to a seminal vesicle near the right border. In some specimens there was a tubular vas deferens without any noticeable enlargement into a seminal vesicle. The vas deferens could be traced forward between the uterus and ovary, and then along the right side of the uterus to the testis. A short distance in front of the seminal vesicle is the seminal receptacle. Along its median line is a yolk duct, and a short distance in front

and near the right side is a small lobed ovary. The vitelline glands appear to fill the greater part of the anterior half of the middle region of the body around the intestinal rami and with a greater dorsal than ventral distribution and are also distributed peripherally over the testes. The testes appear to be diffuse organs lying ventrally in front of the folds of the uterus, extending laterally to the lateral nerves and forward between the posterior intestinal rami. The uterus is conspicuous and fills up the greater part of the posterior third of the body.

Host.- Primary, fish (Kyphosus sectatrix); secondary, unknown.

Location.- Circulatory system

Distribution.- Dry Tortugas.

PART II

SYNOPSIS OF THE FAMILY SPIRORCHIDAE

The blood flukes of the family Spirorchidae have long attracted the attention of parasitologists ~~due to~~ because of their close relationship with those blood flukes, the shistosomes, which are parasites of man and other warm-blooded vertebrates. The family consists of both monostomate and distomate trematodes which are parasitic in the blood-vascular system of turtles. A great many species are found in the United States and are therefore a good source of investigation in the field of helminthology.

Byrd (1939) surveyed and revised the family Spirorchidae, adding descriptions of quite a number of new species from Reelfoot Lake, Tennessee. In this revision many species were reclassified and new genera were created. The paper did not contain descriptions of all the species, only those discovered by Byrd and his associates. The writer has in some cases disagreed with this work, and in these instances the reasons for this disagreement will be given in footnotes.

As a result of the study of the family Spirorchidae, it became apparent that a synopsis of this group would be useful, as the descriptions of many species have been given in publications having a more or less limited circulation. The writer has, therefore, attempted to bring together

descriptions of all the genera and species. Unless stated to the contrary, the descriptions of known species have been compiled from original sources.

Family SPIRORCHIDAE Stunkard, 1921

Synonym.- Proparorchiidae Ward, 1921.

Family diagnosis: Small to medium-sized monostomate or distomate, hermaphroditic blood-inhabiting flukes with weakly developed musculature and suckers. Body with or without hair-like spines. Pharynx absent. Esophagus long, surrounded by gland cells which are particularly prominent near posterior end. Nerve ring usually conspicuous around anterior part of esophagus, giving rise to anterior and posterior nerve trunks. Ceca variable, normally two in number, may be single or joined in middle of body to form a single cecum in posterior half of body, straight to slightly undulating tubes that end blindly near posterior end of body, containing decomposing blood cells. Testes single or separated into follicles, placed in front of or behind ovary or separated into two groups by ovary and genital ducts. Cirrus sac small with weak musculature. Cirrus present or absent. Vesicula seminalis mainly outside cirrus sac. Ovary small to medium sized, spherical, lobed or tubular. Seminal receptaculum and Laurer's canal usually present. Uterus short and non-muscular, with slightly muscular metraterm. Vitellaria follicular, mainly along intestinal ceca, but may spread across body in front of and behind genital field. Ova usually large, spherical or elongated, may or may not possess polar filaments. Miracidia with or without pigmented eyespots. Excretory vesicle short, dividing almost immediately into lateral collecting tubules. Parasitic in vascular system of turtles.

Long rambling. Break up into two sentences.

Subfamily SPIRORCHINAE Stunkard, 1921

Synonyms.- Proparorchiinae Ward, 1921; Hapalotreminae Stunkard, 1921; Unicaecuminae Mehra, 1934.

Subfamily diagnosis.- Spirorchidae: With the characters of the family.

Genus HAPALOTREMA Looss, 1899

Synonym.- Spirhapalum Ejsmont, 1927.

Generic diagnosis.- Spirorchinae: Small distomate blood flukes with hair-like spines on integument. Esophagus long, with undulations or dilations, surrounded by numerous gland cells. Ceca irregular tubes, extending to near posterior end of body. Testes divided into many follicles, separated into two groups by ovary and genital ducts. Seminal vesicle well developed. Cirrus sac small and weakly developed. Genital pore ventral or dorsal, on left side of midline at level of ovary. Laurer's canal present. Ovary between masses of testes, slightly displaced to right of midline, irregular to lobed in outline. Vitellaria follicular, enveloping ceca throughout their length; may or may not form continuous bridge of glands in pretesticular and posttesticular areas. Uterus short. Ova large, with or without long, spirally twisted, polar filaments with thickened ends. Miracidia with or without pigmented eye-spots. Parasitic in heart and large blood vessels of turtles.

HAPALOTREMA POLESIANUM Ejsmont, 1927

Synonym.- Spirhapalum polesianum Ejsmont, 1927.

Specific diagnosis.- Hapalotrema: Oval, great contractibility; 1.18 to 2.3 mm. in length by .38 to .65 mm. wide. Cuticle covered with bacilli-formed hairs. Has 2 oval suckers; oral sucker 69 to 76 u long by 60 to 85 u wide; ventral sucker 65 to 103 u long by 74 to 128 u wide, located in the anterior part of the body toward the center. No pharynx. The esophagus extends posteriorly in a sinuous line taking five or six loops gaining in diameter as it goes posteriorly. The esophagus is enveloped by elongated cellular glands accumulating at its base, giving an impression of an enlargement. At the end of the first fourth and toward the fifth of the body the esophagus bifurcates, sending the ceca to the right and the left for a short distance, where they suddenly curve back to the rear. At the point of bifurcation is a little pouch which constitutes the continuation of the esophagus. The ceca almost reach the posterior end of the body, forming an irregular line in their course.

The nerve commissure joining the two ganglia is located 1/4 of the distance from the oral sucker and the bifurcation of the ceca. From the commissure originate nerve bands going anteriorly and posteriorly.

Excretory vesicle in the form of a curved pipe which does not reach the end of the body.

The testes are gathered in two masses, one anteriorly and one posteriorly, separated by the ovary and genital canals. The anterior mass fills the space between the ventral sucker and the seminal vesicle and is ordinarily composed of six testicular lobes having irregular contours and placed in a broken line, the angles of which are directed toward the two sides of the animal. Often they are so grouped that they seem to form an uninterrupted line. They grow larger as they go posteriorly. The posterior testicular mass is made up of one or two testes closely joined together. The two testicular masses are joined in the seminal vesicle by the aid of a very slender vas deferens. The anterior vas deferens starts at the middle of the anterior testicular mass and goes toward the central part of the seminal vesicle. The posterior vas deferens runs in a median irregular line above the female genital conduits and ovary, and also goes toward the central part of the seminal vesicle opposite the anterior vas deferens. The seminal vesicle has an irregular form and is usually found horizontally and a little askew going from the right side to the left side; it separates the anterior testicular mass from the ovary. The posterior end of the seminal vesicle forms two diverticula and a third narrow tube directed posteriorly entering almost at once a cirrus pouch, this tube being an ejaculatory canal. The rather large cirrus pouch surrounds the ejaculatory canal and the large cirrus can be plainly seen by a marked shrinkage. Prostate cells are absent. The male oriface is in the neighborhood of the female oriface on the ventral side near the left cecal branch and often beneath it.

The female genital apparatus is simple. The ovary is lobed and is situated on the right side of the body beyond the testicular mass, from which it is separated by the testicular mass. Much larger than an undivided testis. The oviduct originates at the middle of the posterior edge of the ovary and goes dorsally, posteriorly, and to the right, and forms an enlargement where the sperm accumulate (receptaculum seminis uterinum). There it turns to the left and slightly forward, where it soon gives rise to a narrow Laurer's canal directed obliquely posteriorly. The oviduct continues its course joining forward of the oötype the Vitelline duct. The uterus is represented only by an oval oötype. Mehlis' body is absent. The oötype is prolonged into the vagine or metraterm which opens under the left intestinal cecum not far from the male oriface. The vitellaria consist of numerous follicles occupying the space between the juncture of the ceca and the end of the body as well as outside of the ceca. The vitellaria join in the region of the posterior testis, completely surrounding it. The transverse vitelline duct originates in two glands ventrally

beneath the genital pores and the ovary, and forms in the central area a vitelline vessel which sends dorsally toward the anterior end of the body a canal opening on the dorsal side into the oviduct forward of the ootype.

The eggs vary in size, being smallest at the time of elimination, 54 to 76 u by 30 to 53 u. The largest forms varied from 100 to 176 u by 68 to 90 u. Miracidia measuring 96 to 138 u by 50 to 74 u were seen in eggs. They were oval, with the anterior end of the body conical. The whole body except the anterior extremity is covered with uniform cilia about 12 u long. The mouth leads to a club-shaped digestive sac. On both sides of the body are found frontal glands. Pigment spots fill the body. Posterior end of the body filled with a large mass of germ cells. Cercaria is unknown or unrecognized.

Hosts.- Primary, turtles (D'emys obicularis L.); secondary, unknown.

Location.- Blood vascular system.

Distribution.- Europe.

HAPALOTREMA LOOSSI Leared, 1862, Price, 1934

Synonyms.- Hapalotrema constrictum Leared, 1862, Looss, 1899.

Specific diagnosis.- Hapalotrema: Body indented at each side near the center, the posterior segment being slightly longer than the anterior. Has an oral sucker, also a large and peculair shaped ventral sucker, which is semi-detached from the body. The oral sucker presents a somewhat radiated appearance, at first giving the idea of an armature of hooklets, but after attentive examination it is seen that no such armature exists. The esophagus is remarkably long and tortuous, leading to a double intestine, which at the outset forms to curves. The separate portions of the intestine then pass down each side of the posterior segment of the body, and after having approximated closely, end in cecal extremities. The space enclosed by the intestine is occupied by large cells. No ova can be seen, but certain apparently rudimentary organs may be detected. The edges of the body show a finely serrated appearance.

Hosts.- Primary, edible turtle; secondary, unknown.

Location.- Heart.

Distribution.- U.S.A. (Washington, D.C.)

HAPALOTREMA SYNORCHIS Luhman, 1935

Specific diagnosis.- Hapalotrema: Size 6 by 1.5 mm. Body covered with spines. Oral sucker 383 u in diameter. Ventral sucker 583 u in diameter and located one-third of the body length from the anterior end. No pharynx; esophagus a long, wide tube, narrowing toward the bifurcation of the ceca. Ceca extend to posterior end of body. Testes numerous, in two large, compactly massed groups, one anterior, the other posterior to the ovary. Seminal vesicle well developed, horizontally placed, immediately anterior to the ovary, and not enclosed in a cirrus sac. Cirrus present. Genital pore surrounded by well-developed genital sucker to the left of, and ventral to, the ovary. Deeply lobed ovary lies almost median between two groups of testes, a little more than two-thirds of the body length from the anterior end. Seminal receptacle small, posterior to ovary. Laurer's canal present. Uterus short, opens at genital sucker. Vitelline ducts large. Vitelline follicles extending from anterior border of ventral sucker to posterior end of body, confluent posteriorly and anteriorly. No eggs in uterus.

Hosts.- Primary, turtle (Caretta caretta); secondary, unknown.

Location.- Heart.

Distribution.- United States (Tortugas, Florida).

HAPALOTREMA MISTROIDES Monticelli, 1896

Synonym.- Mesogonimus mistroides Monticelli, 1896

Specific diagnosis.- Hapalotrema: Small distomate blood fluke with rounded ends. Integument entirely covered with hair-like spines. Esophagus long, undulated, and surrounded with numerous gland cells which in the region of the juncture of the ceca form a compact mass. Ceca irregular tubes extending to the posterior end of the body, where they end blindly. Testes follicular, divided into two groups by the ovary. Anterior testicular mass composed of nine follicles; posterior testicular mass composed of sixteen. Ovary lobed in outline. Vitellaria follicular, enveloping ceca throughout their length, forming a bridge in the pretesticular and postesticular areas. Uterus short. Ova large, without filaments.

Host.- Primary, turtles (Thalassochelys corticata, T. caretta); secondary, unknown.

Location.- Heart.

Distribution.- Europe and Egypt.

Genus SPIRORCHIS MacCallum, 1918

Synonyms.- Proparorchis Ward, 1921; Henotosoma Stunkard, 1922; Haematotrema Stunkard, 1923; Diarmostorchis Ejsmont, 1927; Plasmiorchis Mehra, 1934; and Gomtiotrema Sinha, 1934.

Generic diagnosis.- Spirorchinae: Small to medium-sized monostomate or distomate blood flukes, with unarmed integument. Esophagus long, with gland cells forming a conspicuous area around posterior part. Intestinal tract often with conspicuous median pouch opposite entrance of the esophagus. Ceca ending blindly near posterior end of body. Nerve ring often conspicuous about anterior part of esophagus. Testes indistinctly or distinctly divided into follicles, arranged in linear series anterior to ovary, occasionally with posterior testicular follicle placed posterior to ovary. Vas deferens arising from posterior end of testicular group. Seminal vesicle between ovary and posterior testis, leading into short cirrus sac with weak musculature. Genital pore ventral, left in position, at about level of ovary. Ovary posterior to main testicular mass, close to posterior end of body. Vitellaria follicular, usually occupying all available space in body not occupied by reproductive organs, from esophagus to beyond ends of ceca. Laurer's canal, receptaculum seminis, and small yolk reservoir usually present. Uterus short, containing single ovum. Metraterm weakly muscular. Ova large and spherical, containing miracidia with pigmented eyespots. Excretory bladder short, with short cornua, usually with much coiled reserve vesicle between bladder and genital ducts.

SPIRORCHIS INNOMINATA Ward, 1921

Synonyms.-S. eustreptos MacCallum, 1921; S. emydis MacCallum, 1921; and S. pictae MacCallum, 1926.

Specific diagnosis.- Spirorchis: 4 mm. long and 6 mm. in width near the middle of the body. The oral sucker is broad, measuring 77 u by 54 u. Esophagus passes posteriad in spiral fashion, the coils elongating and enlarging posteriorly, turning five times during its course, the hindmost coil being straighter. Esophagus is narrow at its origin from oral sucker, gradually widening through the first third of its course, being crossed here by the commissure of the nervous system. The region posterior to the commissure is broader, measuring 60 u in ~~width~~. In total length the

the esophagus measures 0.64 mm. Its anterior portion is surrounded by a layer of gland cells, and at the posterior end for a distance of 0.26 mm. there is a deeply staining mass of these cells around the esophagus. The origin of the intestinal diverticula is well shown in the figure. The ceca slightly exceed the esophagus in width, have lobed or crenated walls, and extend almost to the posterior end of the body, where the ends of the ceca approach each other but do not fuse.

The ovary is situated a little to the right of the median line about one-third the distance from the posterior testis to the end of the body. It is lobed, about 0.17 mm. in diameter, and the oviduct arises at its median posterior margin. After about 0.09 mm. it expands into the receptaculum seminis uterinum, which passes posteriad on the right side of the body. The seminal receptacle is about as long as the narrow portion of the oviduct, and then it is obscured by the large transverse duct from the vitellaria. The vitellaria extend as a mass of follicles from the level of the posterior part of the esophagus to the posterior end of the body. They are principally extracecal in position, but extend into the intercecal areas anterior and also posterior to the other reproductive organs. About 0.42 mm. from the posterior end of the body vitelline ducts pass mediad from either side to form a common reservoir. The connection of the vitelline duct with the ootype cannot be distinguished, but from this region the uterus passes forward ventrally and laterally to the genital pore. In the uterus one egg was found which measured 77 u by 48 u. Eggs found in feces contained living miricidia having an average measurement of 108 u by 85 u.

The testes are a rough spiral column filling the whole cavity between the ceca. There is an anterior conical mass and nine other irregularly shaped masses. They begin 0.38 mm. behind the bifurcation of the alimentary tract and extend to within 0.95 mm. from the caudad end of the body. The seminal is conical in shape, its base flush with the posterior face of the last testis, and its apex directed posteriad, ventrad, and sinistrad. It passes underneath and at the left of the anterior median margin of the ovary. The cirrus sac is rather small and opens at the genital pore located beneath the cecum of the left side 0.47 mm. from the posterior end of the body.

Hosts.- Turtles, (Clemmys insculpta = Chelopus insculptus, Pseudemys hieroglyphica reported by Harwood, 1931); secondary, unknown.

Location.- Heart and pulmonary, carotid, and mesenteric arteries.

Distribution.- United States (Oklahoma).

SPIRORCHIS ARTERICOLA Ward, 1921

Specific diagnosis.- Spirorchis: Adult worms vary in size from 1.4 by 0.24 to 2.84 by 0.67 mm. The body is an elongated oval, with the anterior end more nearly pointed and much more mobile than the posterior, and it is often slightly concave on the ventral side. It is relatively thin, but this thinness varies. The oral sucker is oval, longer than broad, and measures from 60 u to 78 u in length and from 42 u to 60 u in width. The esophagus is on the average about one-fifth as long as the body and has the usual gland cells around it. The ceca have no particular features and vary in diameter depending on the amount of material they contain.

The testes are usually ten in number, irregular in shape, oval or lobed, and form a regular consecutive series just behind the center of the body. The testicular area occupies about one-fourth of the width of the body, and from one-third to one-half of this area intervenes between the anterior testis and the bifurcation of the alimentary tract. The two or three anterior testes are situated in the anterior half of the body and the others are located in the posterior half. The distance between the caudal testis and the posterior end of the body is about two-thirds of the distance between the cephalic testis and the anterior end of the body. The seminal vesicle is conical or pyriform, situated immediately behind the caudal testis. The wider end is anterior, and posteriorly it passes underneath the anterior median part of the ovary. This posterior part narrows to a small duct which communicates directly with the cirrus. The cirrus sac is small, musculature weakly developed. The vesicle and the duct form a nearly straight passageway from the posterior testis to the genital pore.

The ovary is a many-lobed organ, situated slightly at the right of the median line a short distance behind the testes. It is somewhat dorsal in position and about one-sixth to one-seventh of the body length from the posterior end. It varies considerably in size. In the smallest sexually mature specimen it measured 67 u by 78 u and in the largest 190 u by 190 u. The yolk glands are exceedingly voluminous. They begin at about the end of the esophagus and extend just a little beyond the posterior ends of the intestinal crura. The cells, though not crowded, form an almost continuous strip or band which lies below and to some extent on both sides of the crura, but only in the immediate proximity of those structures;

for the central area of the body is without yolk cells. At the end of the esophagus and behind the crura, the cells from the two sides approach and become confluent in the median line. Behind the ovary, on the ventral side of the body, the transverse yolk duct joins the two yolk glands, and on it in the median line is found a prominent yolk reservoir. The ducts of the female system show no marked variation from the type usual in the genus. The genital pore is situated below the cecum of the left side about one-seventh of the body length from the posterior end. The eggs vary considerably in size. One present in the uterus of the smallest sexually mature specimen measures 50 u by 35 u and eggs in the uteri of the larger worms measure as much as 75 u by 60 u. The average size of a large number of eggs taken from the feces and containing living miricidium was 86 u by 74 u.

Hosts.- Primary (Chrysemys marginata, C. picta, and Pseudemys scripta. Byrd (1939) collected specimens of this species from Pseudemys troosti, P. hieroglyphica, Chrysemys picta dorsalis, and Graptemys pseudogeographica pseudogeographica. The material differed from that described by Ward (1921) and Stunkard (1923) in the general distribution of the vitellaria which spread across the body in front of the gonads and end almost abruptly just caudal to the level of the ovary. This difference is not deemed of sufficient importance to warrant the separation of this material from S. arteriicola as a separate species). Secondary, unknown.

Location.- Heart and arteries.

Distribution.- U.S.A. (Reelfoot Lake, Tenn.).

SPIRORCHIS HAEMATOBIUM Stunkard, 1922

Synonyms.- Henotosoma haematobium Stunkard, 1922; Spirorchis chelydrae MacCallum, 1926.

Specific diagnosis.- Spirorchis: Elongate, flattened parasites with almost parallel sides, rounded anterior and pointed posterior ends. Crenated margins at anterior end. Living worms from 12.5 mm. extended to 6 mm. contracted in length. Mounted specimens measure from 5 to 9 mm. in length and from 0.48 to 0.75 mm. in width. Cuticula thin and smooth, lacking spines and other modifications. Musculature light and delicate.

Oral sucker only organ of attachment. Situated at anterior tip. Ovoid in shape, measures from 0.077 to 0.1 mm.

in length and from 0.071 to 0.084 mm. in width. Mouth opening subterminal. Esophagus is slightly or exceedingly sinuous, the sinuosity varying with the extent of contraction. In length it measures from 0.39 to 0.77 mm. It increases in diameter posteriorly, although the size of the lumen is not uniform, frequently having one or more dilations. Lining cuticular, and throughout its length the esophagus is surrounded by secretive cells. At the posterior end for about one-fifth of its length the gland cells become more numerous, forming a conspicuous enlarged portion. No pharynx present. Intestinal diverticula arise just before posterior end of esophagus and pass laterad about one-half of the distance to the body wall, where they turn sharply posteriad and extend almost to end of body. Course sinuous.

Excretory pore situated at posterior end of body, and the vesicle divides almost immediately in front to form two lateral collecting ducts which pass anteriorly.

Testes number ten in mature individuals, although after a time certain testes degenerate. They are arranged one after another in intercecal area in posterior half of body. Most anterior testis is about three-fifths of the body length from the anterior end and posterior testis is separated from the posterior end of the body by less than one-half the distance between the anterior and posterior testes. The testes are irregularly lobed, contiguous structures, being flattened antero-posteriorly. They vary in size from 0.12 by 0.27 mm. to 0.27 by 0.43 mm. The posterior testis opens directly into a large ovoid or pyriform seminal vesicle. Broader end anterior and posterior end tapers to a duct which passes on the left side of the body and near the mid-ovarian level enters the cirrus sac. Cirrus sac small and muscular wall slightly developed. Pyriform in shape, wider anteriorly, and the prostate, if present, is represented by only a few cells. Cirrus sac varies in length from 0.154 to 0.22 mm. and in width from 0.05 to 0.077 mm. The genital pore is ventral, just posterior of level of ovary, and situated between cecum of left side. Opening of cirrus is anterior to that of uterus.

The ovary is a lobed oval structure, situated on the right side of the body between the seminal vesicle and the genital pore. It measures from 0.154 by 0.22 mm. to 0.23 to 0.28 mm. The oviduct arises at the median posterior margin and passes dextrad and posteriad; after continuing a short distance it turns mediad where Laurer's canal is given off and the common vitelline duct is received. The ootype region is short, and the tube then passes forward, laterad and ventrad to the genital pore. The vitellaria

are extensively developed and consist of masses of follicles extending from the bifurcation of the alimentary tract almost to the posterior end of the body. They are not lobed but form a continuous sheet of cells extending on the lateral side of the crura throughout their length and filling the intercecal area anterior to the testes and posterior to the vitelline receptacle. Just behind the level of the genital pore vitelline ducts pass mediad on the ventral side of the body and unite to form a large reservoir, the vitelline receptacle, which opens into the oötype through the common vitelline duct.

The uterine portion of the female canal is short and contains a single oval egg. A metraterm is present, although not strongly developed. The eggs are thick shelled, brown in color, and are discharged into the blood vessels. Eggs in the tissue of the host and found in the feces have an average measurement of 0.115 mm. in length by 0.081 mm. in width. They are provided with a cap which opens to allow the escape of the embryo.

Hosts.- Primary, turtles (Chelydra serpentina); secondary, unknown.

Location.- Lungs, pulmonary arteries, heart, mesenteric arteries, and posterior end of aorta.

Distribution.- U.S.A. (Raleigh, North Carolina; New York, N.Y.; New Jersey, N.J.; North Judson, Ind.; Raceland, La.; Reelfoot Lake, Tenn.)

SPIRORCHIS ELEGANS Stunkard, 1923

Specific diagnosis.- Spirorchis: In shape the type specimen is an elongated oval, widest at about the middle of the body. The contracted specimen is oval, slightly wider anteriorly, with somewhat pointed extremities. The longer worm measures 1.71 mm. in length by 0.41 mm. in extreme width, the shorter is 1.15 mm. by 0.62 mm.

The oral sucker of the type specimen is 73 u in length and 62 u in width; that of the contracted specimen is 51 u in length by 81 u in breadth. The esophagus extends through about one-sixth of the body length and conforms to the pattern typical for the genus. The large glandular mass surrounds the posterior third of the esophagus. The intestinal crura are comparatively large, and their course is very sinuous.

The testes are not distinctly separated from one another, and it is difficult to distinguish their limits with certainty. In the contracted specimen they appear to form follicles in a single testis, but in the longer

specimen the testes may be recognized. The testes are deeply lobed, and consequently it is difficult to give precise measurements of individual testes. The group of testes is situated nearly in the middle of the body and extends through slightly less than one-third of the length of the worm. At the center of the series the testes measure 106 u in width, while at the anterior and posterior ends the testes are only about 70 u in width. The distance from the cephalic testis to the bifurcation of the alimentary tract is two-thirds the length of the esophagus. The seminal vesicle and the cirrus sac are clearly visible. The genital pore in both specimens is one-fourth of the body length from the posterior end.

The ovary is conspicuously lobed, slightly larger than any one of the testes, and situated relatively close to the caudal testis. It is on the right side, immediately in front of the level of the genital pore. The oviduct and vagina are visible in both specimens, but the vitelline ducts and receptacle make it difficult to determine the details of the ootype. There is, however, no indication of any variation from the usual form. The vitellaria extend from the level of the bifurcation of the esophagus almost to the posterior end of the body and in front of the testes and behind the vitelline receptacle, occupying the region between the ceca. Neither specimen contained an egg.

Hosts.- Primary, turtles (Pseudemys elegans); secondary, unknown.

Location.- Intestinal blood vessels.

Distribution.- U.S.A. (Havana, Ill., and Oklahoma).

SPIRORCHIS SCRIPTA Stunkard, 1923

Specific diagnosis.- Spirorchis: These worms are almost fusiform in outline; the reproductive organs are large, situated nearly in the middle of the body; and the anterior and posterior ends taper uniformly to rather pointed tips. They vary in length from 0.23 to 0.36 mm. The body is very thin.

The oral sucker is oval, longer than broad, and measures from 64 u by 46 u to 77 u by 54 u. The esophagus is narrow where it joins the oral sucker and increases in width in the anterior half. The posterior half is of an almost uniform diameter. It is slightly sinuous and surrounded by the characteristic glandular cells. The enlarged portion of the gland encloses the posterior third of the esophagus. The median pocket, which extends posteriad and ventrad from the bifurcation of the alimentary

tract, is large and conspicuous, reaching almost to the anterior testis. In all the specimens the ceca are small and almost uniform in diameter.

There are ten testes, forming an almost solid column between the ceca from the posterior end of the esophagus to the seminal vesicle. The testes are large, irregularly oval or lobed, and not always distinctly separated from one another. The testicular area is situated almost exactly in the middle of the body and extends about two-fifths of the total body length. The testes are flattened antero-posteriorly and measure from 80 u to 100 u in width and from 40 u to 80 u in length. The seminal vesicle and cirrus sac conform to the regular pattern and show no peculiar variations. The genital pore is situated about one-fourth of the body length from the posterior end.

The ovary is deeply lobed, about the size of one of the testes, and separated from the caudal testis by slightly less than its width. It is situated at the caudal end of the penultimate fourth of the body. The oviduct arises at the posterior median margin and passes dorsad and dextrad. It soon expands, and the enlarged portion is filled with spermatozoa. This section of the genital duct passes posteriad, and the oötype is about the diameter of the ovary behind it. The vitellaria occupy the usual position, extending from the level of the bifurcation of the esophagus almost to the posterior end of the body. Their ducts pass mediad at the level of the oötype to form a common reservoir which discharges into the oötype just left of the median plane. Immediately before the opening of the vitelline receptacle and slightly right of the median plane, the seminal receptacle branches from the oötype and following an expanded vascular portion a short Laurer's canal opens to the dorsal surface on the median line. The opening of this canal is behind the vitelline receptacle. Eggs in the uterus vary in size from 65 u by 38 u to 77 u by 46 u.

Hosts.- Primary, turtles (Pseudemys scripta, Graptemys pseudographica, Pseudemys troosti, P. hieroglyphica, and Graptemys pseudographica pseudographica); secondary, unknown.

Location.- Mesenteric vesicles, heart, and arteries.

Distribution.- U.S.A. (Raleigh, N.C.; Newton, Texas; Reelfoot Lake, Tenn.).

SPIRORCHIS PICTA Stunkard, 1923[1]

Specific diagnosis.- Spirorchis: Rounded posterior and anterior ends; sides of body throughout most of its length are nearly parallel. Largest specimen 2.33 mm. in length and 0.47 mm. in width; smallest 1.48 mm. in length by 0.35 mm. in width. The oral sucker is large, oval in shape, and longer than broad. It varies in size from 0.046 by 0.038 mm. in the smallest individual to 0.077 by 0.054mm. in the largest. The remaining portions of the alimentary tract are similar in essential respects to those of other species, but the ceca are large and comparatively straight.

The testes are small, distinctly separated, and frequently there is a considerable interval between them. They are lobed, but the indentations are very shallow. With the exception of the one or two most anterior testes they do not differ much in size. The testes are situated almost in the center of the body; the cephalic testis lies about one-third of the body length from the anterior end, the caudal testis about one-third from the posterior end. There is considerable space between the testes and the ceca, and the vitellaria extend into the intercecal area on both sides of the testes and throughout the testicular region. This condition is not present in any other species of the genus. The seminal receptacle is of the usual pyriform type, larger than any one of the testes, and the genital pore is situated one-fourth of the body length from the posterior end.

The ovary is very large, faintly lobed, but almost spherical. In the smallest specimen it is 0.1 mm. in diameter, and in the largest it is 0.2 mm. The ovary has a diameter of about three times that of any testis. The ovary is pressed against the cecum of the right side for a considerable distance and closely approaches the cecum of the left side. The oviduct is short, and the structures of the ootype are compressed into a small area. The genital pore is slightly anterior to the level of the caudal margin of the ovary. The vitellaria are extensively developed and lie on both sides of the ceca throughout their length in front of the ovary and behind the vitelline receptacle. Eggs in the uterus average 77 u by 54 u in size.

[1] Byrd (1939) considered Spirorchis picta Stunkard synonymous with S. elegans, Stunkard maintaining that the general topography of the body of these two species is quite similar in regard to size, the position of the gonads and the genital

Hosts.- Primary, turtles (Chrysemys picta); secondary, unknown.
Location.- Vascular system.
Distribution.- U.S.A. (New York City vicinity)

SPIRORCHIS PARVUM Stunkard, 1923

Synonyms.- Haematotrema parvum Stunkard, 1923.
Specific diagnosis.- Spirorchis: Varies in size from 2.2 by 0.12 mm. to 0.75 by 0.05 mm. The relative length to width is about ten to one, and the thickness is about one-half the width. Posterior end not so mobile as the anterior and is usually rounded, while the anterior end is capable of considerable extension and in this condition becomes narrow and tapering. The greatest width is usually in the region of the testes, although some of the specimens have a widened spatulate region near the posterior end of the body. The cuticula is very thin and the muscular wall of the body extremely delicate.
The oral sucker is large and elongate. It is ovoid in shape, wider anteriorly, and varies in size from 0.073 by 0.035 mm. in the largest specimen to 0.052 to 0.027 mm. in the smallest. The sucker protrudes slightly from the body, and the mouth is subterminal. The digestive system conforms to the type present in the genus. The esophagus is long, extending about one-fifth to one-sixth of the body length; and it becomes sinuous with the contraction

pore, the distribution of the vitellaria, and the number of the testes. Admittedly this species differs from both S. scripta and S. elegans in the relative size of the ovary and testes. It differs from S. elegans in that the testes are not more than one-half the size of the ovary whereas as in S. elegans the ovary is slightly larger than any one of the testes. Of course the size of the genital system varies according to maturity, but here we find a marked difference. Stunkard in his diagnosis said that the vitellaria extend into the intercecal area on both sides of the testes and throughout the testicular region and that this condition is not present in any other species in the genus. The description of S. picta is based on only four specimens; and thus until more material is found, I consider that the original diagnosis is valid.

Evidently an omission here

of the anterior end of the body. It is lined with cuticula; the lumen is relatively large, increasing in size posteriorly. Throughout its length it is enveloped by secretive cells, which are larger and more numerous posteriorly. The posterior end of the esophagus turns ventrally, forming a small median pocket, and the ceca diverge at right angles from the esophagus immediately in front and above the lateral diverticulum. The crura extend laterally about halfway to the body wall and then bend sharply backward, passing almost to the posterior end of the body, where they end blindly. They are small, their diameter hardly exceeding that of the esophagus.

The excretory pore is terminal, the vesicle is very small, and two collecting ducts pass forward. The esophageal commissure and the anterior and posterior ventralis nerves are the only parts of the nervous system visable in whole mounts.

The testes are lobed, oval or spherical bodies of almost equal size situated in the intercecal area. They are situated one behind the other and are distinctly separated. In about one-half the specimens there are five testes, in all others four. They are usually slightly longer than broad and vary from 46 to 57 u in length, from 38 to 50 u in width, and from 32 to 44 u in thickness. The anterior testis is about midway between anterior and posterior ends of the body, and the caudal testis about one-third of the body length from the posterior end. They extend laterally almost to the ceca, filling the intercecal area at the testicular zone. The caudal testis opens into an ovoid or pyriform seminal vesicle, which is about the size of one of the testes. The broader end of the vesicle is forward, and caudally it contracts to form a duct which passes at the left of the ovary and enters the cirrus sac. The cirrus sac turns ventrally and opens at the genital pore. The sac is small and weak; no prostate could be observed; and the genital pore is ventral, at the left of the median line near the level of the posterior margin of the ovary.

The ovary is ovoid, lobed, and situated on the right side of the body immediately behind the seminal vesicle. The broader end is anterior and pressed against the cecum of the right side; the other end is almost in the median plane. In size the ovary measures from 38 by 48 u to 46 by 53 u. The oviduct arises at the posterior end and passes posteriorly on the right side of the body. It has an enlarged portion filled with sperm and then turns toward the median line, where the seminal receptaculum

branches from the duct. The seminal receptacle narrows to form Laurer's canal, which opens to the dorsal surface near the median line. The common vitelline duct opens into the oötype immediately after the origin of the seminal vesicle, and the oötype is followed by the uterus. The vitellaria are well developed and surround the intestinal crura throughout their length, filling the intercrural area anterior to the testes and posterior to the oötype. Median ducts from the lateral masses unite to form the vitelline receptacle that opens into the oötype. Eggs in the uterus measure 54 by 38 u, a tremendous size for so small a worm. The eggs are oval, golden yellow in color, and provided with an operculum.

Hosts.- Primary, turtles (Chrysemys picta); secondary, unknown.

Location.- Blood vessels of intestinal tract, heart and arteries.

Distribution.- U.S.A. (Cold Spring, New York.).

SPIRORCHIS BLANDINGI MacCallum, 1926

Synonyms.- Diarmostorchis blandingi MacCallum, 1926. Ejsmont, 1927.

Specific diagnosis.- Spirorchis: Small, 3 by .71 mm.; differ from others of the Spirorchis group by the fact that one of the lobes of the testes is brought to the rear of the ovary and of the genital pore almost to the posterior end of the body.

Esophagus tortuous, and is surrounded at its juncture with the ceca by a large mass of glandular cells of which some occupy the space between the ceca.

Testes form a more or less spiral column situated between the ceca almost reaching their origin. The isolated lobe is more important than those of the testicular column. It was not possible to follow the vas deferens which continues this lobe. The cirrus pouch starts from the anterior testicular mass; it is rather wide and issues at the genital pore, which is situated laterally on the ventral surface. No distinct seminal vesicle was discovered.

The ovary is round and is located behind the testicular mass on the side opposite the genital pore. No trace of an oviduct or uterus has been revealed. All the specimens examined agreed in this, so that it can be surmised that they are not sexually immature specimens.

Hosts.- Primary, turtles (Emys blandingi Cheloniens);

secondary, unknown.

Location.- Vessels of the lungs (great numbers of eggs were found in the pulmonary tissues).

Distribution.- Eastern United States.

SPIRORCHIS ORIENTALIS Mehra, 1934

Synonyms.- Plasmiorchis orientalis Mehra, 1934; P. pellucidus. Mehra, 1934.

Specific diagnosis.- Spirorchis: The body is elongated fusiform or spindle-shaped, tapering towards the extremities; it is thin especially at the edges, flattened and transparent, with the anterior end a little more pointed than the posterior. The size is very small, measuring 2.26 to 3 mm. in length and .4 to .6 mm. in its greatest breadth, which lies about the middle of the body length. The breadth measures .38 to .5 mm. in the region of the intestinal bifurcation, .27 to .56 mm. in that of the ventral sucker, and .34 to .56 in that of the ovary, varying within the narrow limits of .33 to .4 mm. or .5 to .6 mm. between the intestinal bifurcation and the ovary. The body wall is covered with a very thin cuticle and is devoid of papillae, but is covered with fine needle-like spines, which hardly project outside it. The musculature of the body is poorly developed.

The oral sucker is oval, longer than broad and protrusible, measuring .102 to .108 in length and .066 in maximum breadth. It protrudes ordinarily only a little in front of the anterior end. The ventral sucker is well developed, protrusible and rounded, measuring .128 to .144 mm. in diameter. The ventral sucker lies .192 to .272 mm. behind the intestinal bifurcation and .73 to .75 mm. behind the anterior end. The pharynx is absent. The esophagus, .4 mm. in length and .066 to .069 mm. in breadth, is long and sinuous with two to four bends, extending up to .48 mm. from the anterior end of the body. It is surrounded by deeply staining salivary gland cells, which are found in large numbers around its posterior end. Its inner wall appears plicated on account of the continuous discharge of salivary secretion through it into the lumen; the plications are more pronounced in the terminal part immediately in front of the intestinal bifurcation. At the point where it bifurcates into the ceca, it gives off behind the origin of the latter a small median pocket, the esophageal vesicle. The ceca do not pass laterally

as soon as they arise, but they turn abruptly forward, running one on each side of the esophagus for nearly one-third or one-half of its length and then bend downwards, forming characteristic U-shaped loops as they continue their course to the posterior end. The ceca then run almost straight except for a short outward bend displayed by the left cecum in the region of the genital pore and terminate near the posterior end of the body. They are simple, without diverticula, having a more or less uniform breadth of .075 mm., and lie halfway between the body wall and the median line except near their ends.

The excretory pore is slightly dorsal at the posterior end. The excretory bladder has a very small stem bifurcating into two wider branches, which can be traced up to the blind ends of the ceca. The glandular vesicle which Stunkard considers as the lymph vesicle in the genus Spirorchis is not seen in sexually mature specimens. In immature specimens, however, it is present at the hinder end in the median line behind the vitelline reservoir, having a curved S-shaped appearance.

The main parts of the nervous system are visible in entire mounts. The esophageal commissure is fairly prominent. It lies .096 mm. ~~distantly~~ behind the oral sucker and is slightly swollen on each side to form an indistinct ganglionic mass from which the main lateral nerve arises. The lateral nerve runs posteriorly close outside the ceca on the ventral surface of the body.

The testes, 5 to 7 in number, lie in a linear series in the median plane usually in close contact with one another, almost filling the intercecal area between the ventral sucker and the ovary. They are irregularly lobed, elliptical or ovoid in shape, flattened and broader than long, measuring .14 to .24 mm. in length and .208 to .24 in breadth. The anterior and posterior testes are larger than the middle ones. The anterior testis lies a little behind the ventral sucker, .03 to .12 mm. ~~distance~~ behind it and .033 to .53 behind the intestinal bifurcation. The testicular area occupies a little less than half the length of the body. There is no vas deferens. The vesicula seminalis, filled with sperm, is pear-shaped, with the widest anterior end pressed against the left part of the posterior margin of the hindmost testis, situated usually to the left side and slightly overlapped by the inner margin of the ovary, filling almost the entire space between it and the left cecum. It extends backwards as far as the posterior limit of the ovary or a little behind it to the left cecum, where it enters the cirrus sac, measuring .27 mm. in length and .075 to .105 mm.

in breadth at the anterior end. The cirrus sac is extremely small with poorly developed musculature, somewhat oval or pear-shaped with the narrow end opening at the genital pore, and situated beneath or close inside the left cecum. It contains inside a small vesicula seminalis interna of rounded or oval outline and of .045 mm. diameter, followed by a sharply constricted off ductus ejaculatorius. The latter is pear-shaped, measuring .09 mm. in length and .03 mm. in greatest width near its proximal end. The genital opening lies .28 to .29 mm. ~~diatomae~~ in front of the posterior end of the body and a little behind the ovary to the left side beneath the left cecum. The cirrus sac opens anteriorly to the metraterm at the genital pore. The prostate gland cells are absent.

The ovary is much lobed, and lies median or slightly to the right side, with its outer wall close inside the right cecum, immediately behind the hindmost testis at a distance of .4 to .6 mm. from the posterior end of the body. It overlaps partly or entirely the basal part of the vesicula seminalis, measuring .24 by .176 mm. or .176 by .112 mm. or .9 by .9 mm. in size in the three specimens examined. The oviduct originates from the middle of its posterior margin, and after running a short distance dorsally backwards, joins the receptaculum seminis, which is filled with sperm. The receptaculum seminis is of an oval or spherical shape, and lies to the right side close behind the ovary, measuring .045 to .06 mm. in length and .05 to .075 mm. in maximum breadth. The oviduct leaves the latter at the posterior end, and receives the small Laurer's canal; it then continues its course slightly to the left side, a little behind the level of the genital opening, to receive the yolk reservoir, where it sharply turns forward to open into the broad oval ootype of the uterus, which contains a single large ovum. The uterus lies transversely, close in front of the union of the transverse vitelline ducts, behind the receptaculum seminis, and enters terminally into a small metraterm with thin muscular walls. The latter opens to the exterior at the genital pore. The ovum is large, non-operculated, and oval, without filaments or spines; it measures .102 to .12 mm. in length and .042 to .057 mm. in maximum breadth.

The vitellaria are voluminous, and occupy lateral areas surrounding the ceca, extending from the middle of the esophagus to almost the posterior end of the body. The follicles of small size lie mainly outside the ceca, forming a continuous linear mass, the extracecal areas; but they also enter the intracecal region both dorsally

and ventrally to form intracecal areas. At the posterior end they generally meet in the intracecal region behind the blind ends of the ceca. The transverse vitelline ducts arise slantingly at about the level of the genital opening and unite closely behind the uterus near the ventral wall to form the backwardly directed vitelline reservoir, the narrow anterior end of which bends forward on the dorsal side to open into the oviduct, near its juncture with the uterus.

Hosts.- Primary, turtles (Kachuga dhongoka); secondary, unknown.

Location.- Ventricle of heart

Distribution.- Allahabad, India.

SPIRORCHIS HARDELLII Mehra, 1934

Synonyms.- Plasmiorchis hardellii Mehra, 1934; P. obscurum Mehra, 1934.

Specific diagnosis.- Spirorchis: The body is thin, transparent, elongated and elliptical in shape with rounded anterior and posterior ends; the anterior end is generally broader and more rounded, but sometimes it is bluntly pointed. It measures 3.85 to 5.28 mm. in length and 1.18 to 1.57 in breadth in the mid region of the body. The body wall has a thin muscular layer, which is covered outside by a thin cuticle. It is devoid of papillae, but it is armed with fine needle-like spines, which hardly project outside it.

The oral sucker is longer than broad and slightly protrusible, measuring ordinarily .24 mm. in length and .176 mm. in maximum width. The ventral sucker is broader than long and about double the size of the oral sucker, measuring .3 to .4 mm. in length and .36 to .64 mm. in maximum breadth. It is muscular, having a well-developed layer of radial muscles with an outer thin layer of longitudinal muscle fibers, and lies .29 mm. ~~distance~~ behind the intestinal bifurcation. The pharynx is absent. The esophagus is long and slightly undulating with two or three bends, measuring .67 to .96 mm. in length. It gradually increases in breadth as it goes posteriorly and is surrounded by deeply staining salivary gland cells, which are found in much larger numbers around its posterior end. Its inner wall is plicated as in S. orientalis. The esophageal vesicle is well developed. The intestinal ceca arise at the juncture of the vesicle with the esophagus, and soon turn forward to form loops similar to those found in S. orientalis, which run parallel to the esophagus from the

posterior three-fourths of its length. The ceca are of a much narrower calibre than the esophagus and possess small, irregular diverticula, and form well-defined loops in the region of the genital opening close behind the ovary before they terminate near the posterior end of the body.

The excretory opening lies dorsally a little in front of the posterior end. The excretory bladder has a short median stem, which bifurcates into two long, narrow ducts running one on each side outside the ceca throughout the body length. The glandular vesicle is a large, convoluted, tubular mass, occupying the entire intracecal space behind the genital loops of the ceca, and measuring .54 mm. in length and .51 mm. in breadth near its anterior end. The glandular tubular mass ends blindly in the body.

The nervous system resembles closely that of S. orientalis. The esophageal commissure lies close in front of the anterior limits of the anterior loops of the intestinal ceca, .21 mm. ~~distance~~ behind the anterior end of the esophagus.

The testes, 19 to 21 in number, lie in a linear series in the median line, .064 to .096 mm. ~~distance~~ behind one another, separated on either side by a moderate distance from the corresponding intestinal cecum. They are much broader than long, with a characteristic band-like irregular form, narrow antero-posteriorly, thicker in the middle, pointed or notched at their lateral ends, and produced into one or two very short-pointed outgrowths near the middle region. The largest testis, situated at the middle of the row, measures .032 mm. in length and .4 to .48 mm. in maximum breadth. The foremost testis lies a little behind the ventral sucker; the hindmost testis lies a little in front of the ovary and at a distance of .88 mm. from the posterior end of the body. The testicular area occupies a little less than half the length of the body. The vas deferens is absent, and the vesicula seminalis is poorly developed. The cirrus sac is large and muscular, situated obliquely with the basal end near the median line just in front of, or level with, the anterior margin of the ovary.

The ovary lies to the right side closely inside the right cecum, .112 mm. behind the posterior testis. It is irregularly lobed and small in size, measuring .075 to .08 mm. by .09 to .2 mm. The oviduct arises from its inner margin and runs backwards for a short distance, to become enlarged into the receptaculum seminis, which is somewhat pear-shaped, measuring .072 to .075 mm. by .03 to .033 mm. It becomes narrowed at its posterior end to

pass into the uterus, which runs transversely from the median line to the left side. The uterus, .108 by .021 to .024 mm., is thin walled lined with parenchymatous cells, and passes at its terminal end into the metraterm of .108 mm. length, which is lined internally with a thin cuticular layer. The shell gland cells are absent. A small, inconspicuous Laurer's canal is present. The ovum is large, elongated oval in shape, and non-operculated without filaments, measuring .081 by .03 mm. Only one ovum is contained at a time in the uterus of the metraterm.

The vitellaria are well developed, situated laterally, ~~and~~ commencing a little in front of the middle of the esophagus and terminating at the blind ends of the ceca. The follicles are small and are mostly aggregated outside the ceca, extending slightly inward in the lateral areas outside the testicular zone. The transverse vitelline ducts lie just in front of the convoluted glandular vesicle. The vitelline reservoir lies immediately behind the transverse ducts in the median line, ending blindly just in front of the glandular vesicle.

Hosts.- Primary, turtles (Hardella thurgi and Kachuga dhongoka); secondary, unknown.

Location.- Ventricle of heart and aortic arches.

Distribution.- Allahabad, India.

SPIRORCHIS SANGUINA Sinha, 1934

Synonym.- Gomtiotrema sanguina Sinha, 1934.

Specific diagnosis.- Spirorchis: A hermaphroditic distome, elongated and flattened in form. It is widest in the region of the testes, gradually tapering towards the anterior end. The body is thin and transparent, 4.13 mm. in length and .41 mm. in greatest width. The body is covered with a thin cuticle devoid of spines or hooks and inturned at the oral sucker, the genital pore, and the excretory pore. The oral sucker is situated at the extreme anterior end of body, protrusible, oval in shape, with about one-half protruding, .125 mm. long by .075 mm. wide. The Ventral sucker is circular, protrusible, is situated about one-third the distance from the anterior end of the body, and is .105 mm. in diameter. The oral sucker leads into a long esophagus, which follows a sinuous course to the point of its bifurcation into the intestinal ceca. It is .53 mm. long, and is surrounded by a layer of gland cells forming a

compact glandular mass around the posterior one-fourth of esophagus. Posteriorly, the esophagus is produced into a pocket-like structure that hangs freely in the parenchyma. The intestinal ceca arise in front of the median pocket from the esophagus and run forwards anteriorly for a short distance and curve backwards, thereby forming a loop at the point of their origin. The ceca run backwards almost parallel to the body wall and extend up to the posterior end of the body. Just before their termination posteriorly, they bend inward for a short distance and then run backward; they are slender tubes of a more or less uniform diameter.

The excretory pore is situated at the posterior end of the body, slightly dorsal in position. It leads into two elongated collecting ducts which pass forward laterally to the ends of the intestinal ceca, where they narrow out to form the longitudinal ducts running dorsally to the ceca on either side of the body. The female reproductive system consists of a single dome-shaped ovary, tri-lobed posteriorly, situated .51 mm. in front of posterior end of body, and is .25 mm. by .22 mm. in size. The oviduct arises from middle lobe of the ovary at posterior end, and passes on right side of body; after a short course it receives the common vitelline duct from the vitelline reservoir and forms the oötype. The Receptaculum seminis and Laurer's canal also meet it at this point, and the latter opens to the outside on the dorsal surface behind the region of the vitelline reservoir. The point of union of all these ducts is further marked by the presence of minute shell gland cells, arranged radially about the oötype. The vitellaria are voluminous and well developed. They consist of masses of follicles on either side of the intestinal ceca, from the oral sucker to the posterior end of the body, but in front of the acetabulum and behind the vitelline reservoir they fill up all the spaces. Behind the genital pore the ducts from the vitellaria unite together by transverse ducts to form the vitelline reservoir, from where the common vitelline duct takes its origin and opens at the oötype. The uterus is short, arising from the oötype, opening at the lateral side of body at the genital pore situated outside the left intestinal cecum. A single large egg found in uterus, .088 mm. long by .050 mm. wide, bearing a knob-like projection at one end and provided with a thick shell of golden brown color.

The male reproductive system consists of twelve testes, arranged in a linear series in the intercecal

space. The anterior two testes are separated from each other and also from the rest, but the remaining ten testes are joined end to end. They occupy a region 1.74 mm. in length, the anterior testes being at a distance of 1.58 mm. from the anterior end of the body. They are roughly oval to spherical in shape and vary in size. The vesicula seminis lies directly behind the posterior testes, touching the latter. It is widest anteriorly, and gradually tapers posteriorly to form a narrow ductus ejaculatorius. The latter opens at the genital pore besides the female opening, on the left side of the body at a distance of .45 mm. from the posterior end.

Hosts.- Primary, turtles (Hardella thurgi Gray); secondary, unknown.

Location.- Vascular system.

Distribution.- Lucknow, River Conti, India.

SPIRORCHIS BLANDINGIOIDES Byrd, 1939

Specific diagnosis.- Spirorchis: Small monostomate blood flukes with rounded ends and almost parallel sides. The body is from 0.86 to 1.20 mm. long by 0.22 to 0.28 mm. in greatest width. The oral sucker is 55 to 80 u long by 55 to 60 u wide, and protrusible. The esophagus is long, from 170 to 320 u long by a maximum width of 70 u at its posterior end, and surrounded by numerous gland cells that are more compact around the posterior end. The nerve ring is prominet. There is a digestive tract with a prominent median pouch posterior to entrance of the esophagus. The ceca are long, with irregular margins and few undulations, ending approximately halfway between genital pore and the posterior end of the body. The testes are 9 or 10 in number, and separated into distinct follicles, the last follicle of which may lie anterior to, to one side of, or immediately posterior to the ovary. In two of the four specimens it lies posterior to ovary; anterior group of follicles arranged in linear series anterior to ovary, beginning 50 to 110 u behind bifurcation; follicles small, 20 to 50 u long by 26 to 50 u wide, irregular in outline. Cirrus sac small, inconspicuous. Vesicula seminalis anterior to ovary, outside cirrus sac. Genital pore ventral, just inside left cecum, close behind level of ovary. Ovary irregular to deeply notched in outline, larger than a testicular follicle, from 80 to 160 u in diameter, placed 260 u in front of caudal end of body. Oviduct short. Ootype, shell gland, Laurer's canal,

and seminal receptaculum present. Vitellaria follicular, filling all available space in body not occupied by other organs, from bifurcation of ceca to ends of ceca. Small yolk reservoir present at union of two transverse vitelline ducts, close behind uterus. Uterus short. Metraterm slightly muscular. Ova unobserved. Excretory system typical, with reserve vesicle.

Hosts.- Primary, turtles (Pseudemys troostii Holbrock) and P. hieróglyphica); secondary, unknown.

Location.- Mesenteric circulation.

Distribution.- U.S.A. (Reelfoot Lake, Tenn.).

SPIRORCHIS PSEUDEMYAE Byrd, 1939

Specific diagnosis.- Spirorchis: Small monostomate blood flukes with rounded ends and almost parallel sides. Body from 1.16 to 1.43 mm. long by 0.43 to 0.58 mm. wide. Oral sucker 130 u long by 100 u wide, slightly protrusible. Esophagus 300 to 380 u long by 70 u wide in posterior part, with many undulations, surrounded by gland cells that form compact mass around posterior half of esophagus. Nerve ring prominet, in region close behind oral sucker, giving rise to prominent posterior nerve trunks that can be traced to near posterior end of body. Digestive tract with conspicuous median pouch posterior to entrance of esophagus. Ceca irregular in outline, with few undulations, ending near posterior end of body. Testes 10 in number, small, 90 u long by 55 u wide, arranged in linear series in midline anterior to ovary, beginning about 200 u behind bifurcation of ceca. Vesicula seminalis separating ovary from posterior testicular follicle, outside cirrus sac, passing around left side of ovary to cirrus sac. Cirrus sac small, weakly muscular, about 100 u long. Genital pore ventral, to left side of midline just inside left cecum, on level with caudal boundary of ovary, 300 u from posterior end of body. Ovary large, 200 u long by 140 u wide, more than twice as large as testes, deeply lobed. Oviduct, ootype, Laurer's canal, seminal receptaculum, shell gland, and yolk reservoir present. Vitellaria follicular, extensive, from just behind nerve ring to beyond ends of ceca, filling all available space not occupied by other organs. Uterus short, with weakly developed metraterm. Ova 70 u long by 42 u wide. Excretory system typical. Reserve vesicle prominent and much coiled, extending from crotch of bladder to genital ducts.

Hosts.- Primary, turtles (Pseudemys troostii Holbrook);

secondary, unknown.
Location.- Mesenteric circulation.
Distribution.- U.S.A. (Reelfoot Lake, Tenn.).

SPIRORCHIS MINUTUM Byrd, 1939

Specific diagnosis.- Spirorchis: Small, delicate, monostomate blood flukes with bluntly rounded posterior ends and tapering anterior ends. Unarmed. Body elongated, threadlike, from 0.70 to 1.00 mm. long by 0.08 to 0.10 mm. in maximum width. Oral sucker small, 35 u long by 26 u wide, protrusible. Esophagus long, narrow, 190 u long by 25 u wide, surrounded by gland cells. Gland cells more compact around posterior third of esophagus. Nerve ring present, inconspicuous. Digestive tract with inconspicuous median pouch opposite entrance of esophagus. Ceca irregular in their course, rather smooth in outline, extending to within 20 u of posterior end of body. Testes 10 in number, distinct, rather large, 35 u long by 70 u wide, beginning at middle of body, arranged in linear series in front of ovary. Vesicula seminalis small, lying between ovary and caudal follicle of testes. Cirrus sac about 100 u long, slightly muscular, with prostatic gland cells. Genital pore ventral, just inside left cecum, on level with caudal boundary of ovary, approximately 115 u from posterior end of body. Ovary slightly larger than a testicular follicle, cup-shaped, 52 u long by 70 u wide, widely separated from testes. Short oviduct, ootype, receptaculum seminis, and Laurer's canal present. Vitellaria follicular, extensive, from bifurcation to ends of ceca, in all available space not occupied by other organs. Small yolk reservoir present behind genital ducts. Uterus, with slightly muscular metraterm. Ova not observed. Excretory system typical, with prominent, much coiled reserve vesicle between yolk reservoir and excretory bladder.
Hosts.- Primary, turtles (Chelydra serpentina); secondary, unknown.
Location.- Mesenteric circulation.
Distribution.- U.S.A. (Reelfoot Lake, Tenn.).

SPIRORCHIS MAGNITESTIS Byrd, 1939

Specific diagnosis.- Spirorchis: Medium sized monostomate blood fluke with rounded extremities and almost parallel sides. Body extremely flat and weakly muscular,

from 4.80 to 5.00 mm. long by 1.00 mm. wide. Unarmed. Oral sucker 70 u in diameter, protrusible. Esophagus 350 u long, irregular, surrounded by gland cells. Gland cells forming compact mass around posterior third of esophagus. Nerve ring small, around esophagus in anterior third. Digestive tract with prominent median pouch opposite entrance of esophagus. Ceca much pouched giving a jagged appearance on both the outer and inner margins, passing through irregular course to very near posterior end of body. Testes large, much lobed and irregular in outline, follicles not distinctly separated; testicular mass extending from near ovary to within 1.10 mm. of bifurcation, 2.10 mm. long by 0.76 mm. wide. Vesicula seminalis large, widely separating ovary from testes, passing around right side of ovary to genital pore. Cirrus sac long, narrow, with weakly developed musculature. Genital pore ventral, just inside left cecum, slightly caudal to level of ovary, about 300 u from posterior end of body. Ovary small, 240 u long by 190 u wide, with two main lobes, about 460 u from posterior end of body, close beside left cecum. Oviduct, ootype, receptaculum seminis, shell gland, Laurer's canal, and yolk reserve present. Vitellaria follicular, extensive, from just in front of bifurcation to posterior end of body, filling all available space not occupied by other organs. Uterus short, with weakly developed metraterm. Ova in tissue adjacent site of worms very large, 140 u long by 85 u wide (no ova were observed in uterus of worms). Excretory system typical, with conspicuous and much coiled reserve vesicle.

Hosts.- Primary, turtles (Chelydra serpentina); secondary, unknown.

Location.- Wall of heart.

Distribution.- U.S.A. (Reelfoot Lake, Tenn.).

Genus HAPALORHYNCHUS Stunkard, 1922

Synonyms.- Coeuritrema Mehra, 1933; Tremarhynchus Thapar, 1933.

Generic diagnosis.- Spirorchinae: Small distomate blood flukes, with or without hair-like spines covering the integument, usually with constriction in body at level of ventral sucker. Suckers small and protrusible. Esophagus long, with gland cells. Gland cells usually forming compact mass about posterior part of esophagus. Nerve ring small. Ceca simple, with or without undulations, reaching to very near posterior end of body.

Testes two in number, separated by ovary. Vesicula seminals usually large, anterior to anterior testis, outside cirrus sac. Cirrus sac small, weakly to moderately muscular, usually with short cirrus. Genital pore dorsal, to left of midline, on level with or slightly anterior to anterior testis. Ovary between testes. Oviduct, shell gland, receptaculum seminis, and small yolk reservoir usually present. Vitellaria follicular, extensive, mainly along length of ceca. Uterus short with weakly developed metraterm. Ova spherical or elongated, with or without polar processes, discharged singly. Excretory system with median terminal bladder, more conspicuous than in Spirorchis, with or without reserve vesicle. Cornua reaching to region of oral sucker. Parasitic in blood vascular system of turtles.

HAPALORHYNCHUS GRACILIS Stunkard, 1922

Specific diagnosis.- Hapalorphynchus: Length 1.5 to 1.9 mm. and width 0.15 to 0.23 mm. Fusiform in shape, tapering anteriorly and posteriorly in a similar manner. Region of greatest width is near middle of body where reproductive organs are located. Before and behind the limits of the vitellaria the body narrows considerably. In cross section the body is oval, flattened ventrally. Cuticula thin and unarmed. Musculature weak and poorly developed. Acetabulum slightly protrusible but not stalked and situated near posterior end of anterior third of body. Cup-shaped, normally circular in outline but sometimes elongated or flattened. Measures from 0.061 to 0.069 mm. in diameter and its depth is approximately equal to its diameter. Oral sucker slightly subterminal and capable of considerable extension and retraction, usually about one-half of the sucker protrudes from the body. In shape it is ovate, wider anteriorly, and measures from 0.073 to 0.084 mm. in length and from 0.054 to 0.058 mm. in width. The esophagus extends posteriorly from the oral sucker to the bifurcation of the alimentary tract midway between the oral and ventral suckers. Lining cuticular and surrounded by secretive cells. No pharynx present. Digestive ceca meet anteriorly to form an angle and end blindly about one-fifth the body length from the posterior end. They are somewhat dorsal in position and the left crux is flexed median and dorsad near the middle of the body, passing on the median side of the genital pore. Excretory pore located at posterior end of body, and a large collecting vesicle passes forward dividing a short distance behind the intestinal crura to form two

lateral collecting ducts.

The testes are situated one behind the other before the ovary. The posterior testis is the larger; it has an elongated oval form and measures 0.18 to 0.21 mm. in length, 0.05 to 0.06 mm. in width, and 0.06 to 0.07 mm. in depth. The anterior testis is situated obliquely, immediately in front and slightly at the right of the ovary. It is ovate to triangular in outline, the widest portion is anterior and median and the organ narrows laterally and posteriorly. The posterior end occupies the right side of the body at the ovarian level. Its long axis measures from 0.064 to 0.084 mm. and its transverse axis 0.04 to 0.05 mm.

There is a large seminal vesicle which extends from the level of the acetabula, about one-half of the distance posteriad to the ovary. On the right side it has an indentation and is partially covered by a lobe of the vitellaria. From the median posterior margin of the vesicle the vas deferens emerges as a small tube. It enlarges almost immediately and passes posteriad, dorsad and sinistrad to the genital pore. The pore is double, the male and female canals opening separately, although the wall separating them is very thin and they seem to discharge through a single orifice. A cirrus sac and cirrus are lacking. The vas deferens and the terminal part of the seminal vesicle are enclosed in a large prostate gland which occupies most of the body space between the anterior testis and the seminal vesicle.

The ovary is situated slightly at the left of the median line and posterior to the middle of the body. Its long axis is almost at right angles to the long axis of the worm. It measures from 0.1 to 0.12 mm. in length and 0.06 to 0.08 mm. in extreme width. It is ovoid to pyriform in shape, the wider end is lateral and slightly anterior and the oviduct arises at the median posterior margin. The oviduct passes posteriad almost to the level of the posterior testis. Here it gives off a small seminal receptacle and Laurer's canal which passes dorsally opening to the surface near the median line. Immediately following the origin of Laurer's canal, the vitelline duct discharges into the ootype and the canal then passes forward on the dorsal side of the body and leads directly to the genital pore. The vitellaria consist of masses of follicles extending on either side of the body from the bifurcation of the alimentary tract to the bifurcation of the excretory vesicle. They extend to the median line forming a solid mass in front of the acetabulum and behind the ovary except for a small area where the posterior

testis limits their presence.

The genital pore is dorsal in position, situated near the middle of the body, slightly to the left of the median line. The diverticulum of the intestine and the vitelline tube of that side are bent mediad to the level of the pore, and lie median to it.

The uterus is short, only one egg found. Considering size of egg it appears certain that not more than one egg can be present in uterus at one time. The egg is tricornuate, the shell is thick and resistant to pressure although almost colorless. The eggs reach the outside world with the feces of the host and are often present in large numbers. Eggs in the feces measure 0.27 mm. in length by 0.07 mm. in width at level of embryo and 0.2 mm. between tips of posterior horns.

Hosts.- Primary, turtles (Chelydra serpentina); secondary, unknown.

Location.- Lungs, portal and mesenteric vessels.

Distribution.- U.S.A. (North Judson, Ind.).

HAPALORHYNCHUS LYSSEMUS Mehra, 1933

Synonym.- Coeuritrema lyssemus Mehra, 1933.

Specific diagnosis.- Hapalorhynchus: The body is thin and very transparent, somewhat conical in shape, broad and somewhat rounded near the posterior end and narrow in front of the ventral sucker coming to a blunt point at the antterior end. The size is small, 1.53 to 1.92 mm. in length by .46 by .48 mm. in its greatest breadth in the region of the ovary. The posterior end is usually spatulate and flattened depending upon the amount of contraction and notched in the center where the excretory bladder opens. The body wall is covered with small conical papillae or tubercles which extend from a little distance behind the oral sucker to the posterior end. They are sparse in front of the intestinal bifurcation, but behind the acetabulum they are numerous and more closely situated. Their free ends are somewhat rounded or bluntly pointed and directed straight outwards or upwards, but not backwards like the usual chitonous spines. The small rod-shaped spines characteristic of the blood flukes are present only in the region of the genital pore and the cirrus sac.

The oral sucker is terminal and partly projects out from the anterior end above the general surface of the body. It has a circular outline, measuring .1 to .12 mm. in diameter; occasionally it is a little longer than broad. The ventral sucker is much larger and stouter,

measuring .17 to .19 mm. in diameter. The ventral sucker lies close behind the intestinal bifurcation at about one-third the body length from the anterior end, occupying nearly the entire depth and a great portion of the breadth of the body, and has the form of a deep cup with a short base capable of entire protrusion from the body surface. The pharynx is absent. The esophagus is straight and of more or less uniform breadth, measuring .195 to .256 mm. in length and .045 to .075 mm. in breadth. It is closely surrounded by salivary gland cells, which are found in large numbers forming a bulbous mass before it passes into the intestinal bifurcation; the gland cells are also found in large numbers around its anterior end. The intestinal ceca turn backward soon after their origin and extend to a little distance from the posterior end. They are pressed closely against, or slightly overlapped by the ventral sucker, behind which they converge inwards toward each other mesially, the left curving more deeply than the right, but soon turn outwards to occupy the lateral position. Behind the posterior testis they again undulate twice or thrice but less markedly than before. The ceca are very narrow around and a little behind the ventral sucker. The genital opening lies dorsally to the left side of the body outside the left intestinal cecum, halfway between the median line and the left body margin, in the region enclosed by the first characteristic loop of the left cecum, a little distance, .13 mm., behind the ventral sucker and a little in front of the middle of the body.

The testes, two in number, lie in the posterior half of the body with the ovary between them. The anterior testis lies on the right side close to the right intestinal cecum and close behind the cirrus sac, .288 mm. behind the ventral sucker and .62 mm. from the posterior end. It is roughly triangular or somewhat heart-shaped with a broad flat or slightly concave anterior margin and a narrow rounded or somewhat bluntly pointed posterior end, and measures .14 to .16 mm. in length, .14 to .176 mm. in greatest width, and .144 mm. in depth. The ovary lies between the two testes, immediately behind the anterior testis and in front of the posterior testis to the left side of the median line with its outer wall pressed closely inside the left intestinal cecum. It is not much lobed but has a triangular or somewhat oval form with an inwardly directed process or lobe from which the oviduct arises, measuring .12 to .18 mm. in length, .05 to .01 mm. in greatest breadth, and .051 to .11 mm. in depth; the lobe arises from its mesial surface, a little behind or about the middle of its length. The ovary appears as a compact mass of ova of large size, .024 to .027 mm. in diameter.

The oviduct lies in the median line. The receptaculum seminis, .09 mm. in length and .033 mm. in greatest width, is a somewhat spherical or pear-shaped sac filled with sperm and lies to the right side immediately in front of the posterior testis. Laurer's canal arises from the inner side of the receptaculum seminis, near the point where the later joins the oviduct and opens to the exterior dorsally, slightly to the left of the median line and a little in front of the posterior margin of the ovary. The transverse vitelline ducts lie between the ovary and the posterior testis in front of the receptaculum seminis, near the ventral body wall. The vitelline reservoir lies in front of the transverse ducts in the median line or slightly to the right side and opens into the oviduct before the receptaculum seminis joins it. The oviduct after its juncture with the receptaculum seminis passes into a thin-walled uterus, situated between the ovary and the anterior testis. The uterus is small and indistinguishable from the metraterm except by the absence of musculature in its walls. The metraterm is strongly muscled and well developed, measuring .27 to .32 mm. in length; it commences between the ovary and the anterior testis, in front of which it runs parallel to the cirrus sac, crossing the left intestinal cecum to open to the exterior at the dorsally situated genital pore. The posterior testis lies close behind the ovary and receptaculum seminis in the median plane of the body, .384 mm. in front of the posterior end of the body. It is somewhat lobed, ovoid or rounded in shape, broad in front and narrow behind, measuring .12 to .176 mm. in length, .084 to .16 mm. in greatest breadth, and .075 to .12 mm. in depth, occupying the entire depth of the body and the space between the ceca.

The cirrus sac is large and thick-walled composed of circular muscle fibers, and is situated obliquely in the median line, in the anterior part of the genital field. It has a characteristic retort-shaped or flask-shaped appearance, and measure .15 to .24 mm. in length and .045 to .084 mm. in greatest width. The gesicula seminalis is nearly spherical, pear-shaped or oval in outline, situated outside the cirrus sac. It has thin parenchymatous walls and is filled with sperm, measuring .048 to .057 mm. in length and .024 to .042 in greatest breadth. The pars prostatica lies within the cirrus sac as a narrow tube surrounded by a vacuolated mass of gland cells. The cirrus is well developed and easily protrusible. It is an elongated cylindrical organ, swollen at the free terminal end and narrow at the base, lying flat on the dorsal surface of the body near the left body margin.

The vitellaria commence behind the acetabulum and terminate near the posterior end just behind the blind ends of the ceca. They lie mainly outside the ceca covering them dorsally and ventrally, but immediately behind the acetabulum and the posterior testis they extend inward uniting mesially, leaving, however, entirely uncovered the genital field and the excretory bladder. The follicles are large in size and closely crowded together. The transverse ducts arise between the ovary and the posterior testis and unite to form in front the vitelline reservoir. Only one ovum is contained at a time in the uterus or in the proximal part of the metraterm. The ovum is large, somewhat oval in shape, and produced into a narrow filament at each end, measuring .168 mm. in length with filaments, .096 mm. without filaments and .027 to .03 mm. in greatest width.

The excretory bladder is short but prominent, situated at the posterior end of the body in the median plane, behind and a little in front of the blind ends of the intestinal ceca. It consists of a short median stem, which bifurcates anteriorly into two short cornua lying near and parallel to each other. The main stem also gives off laterally two lobe behind each other on each side near the bifurcation. The excretory opening is terminal, situated in the middle of the notch at the posterior end of the body.

Host.- Primary, turtles (Lissemys punctata syn. Emyda granosa); secondary, unknown.

Location.- Ventricle of heart.

Distribution.- Allahabad, India.

HAPALORHYNCHUS ODHNERENSIS Mehra, 1933

Synonym.- Coeuritrema odhnerensis Mehra, 1933.

Specific diagnosis.- Hapalorhynchus: The body is thin, delicate and very transparent, measuring 1.5 mm. in length, .224 mm. in maximum breadth in the genital field, .176 mm. in breadth in the region of the ventral sucker, and .16 mm. in that of the intestinal bifurcation. It is narrow and elongated with bluntly pointed ends. The posterior end is not broad and notched in the middle as in H. lyssemus, from which this species differs markedly in the shape of its body. The body wall is entirely free from tubercles or papillae.

The oral sucker is larger than the ventral sucker, measuring .087 mm. in length and .075 mm. in breadth. It lies terminally at the anterior end and is much

protrusible. The ventral sucker is delicate, measuring .06 mm. in length and .072 mm. in breadth, and lying in front of the posterior limit of the first third body length. The pharynx is absent. The esophagus measures .27 mm. in length and .08 mm. in maximum breadth, and is surrounded by salivary gland cells, which lie in much larger numbers around the intestinal bifurcation. The intestinal ceca run backwards as soon as they arise, surrounding closely the ventral sucker and terminate near the posterior end of the body just in front of the short main stem of the excretory bladder.

The excretory opening lies at the posterior end of the body. The excretory bladder is narrow and tubular situated at the posterior end of the body just behind the blind ends of the ceca; the main stem of .1 mm. bifurcates into two short cornua. One small rather inconspicuous lobe is given off on each side from the main stem just behind the point of bifurcation.

The genital opening lies dorsally to the left side .99 to 1 mm. distance behind the ventral sucker. The testes, two in number, lie in the posterior half of the body with the ovary between them and are distinctly lobed. The anterior testis lies immediately behind the cirrus sac and is irregularly lobed and rounded, measuring .105 mm. in diameter. The ovary lies between the testes and has a characteristic flask-shaped outline with the neck part directed mesially and the main body part of an oval shape. The narrow mesially directed part is continued into the oviduct. The receptaculum seminis filled with sperm lies to the right side opposite to the ovary and immediately in front of the posterior testis. The transverse vitelline ducts and the vitelline reservoir lie close behind the ovary, between it and the posterior testis. The posterior testis lies median, .454 mm. in front of the hinder end and immediately behind the ovary and the receptaculum seminis; it is lobed like the anterior testis, measuring .096 mm. in length and 1.02 mm. in greatest breadth.

The cirrus sac is well developed with stout muscular walls, situated close in front of and pressing behind the anterior testis; it is crescent-shaped with a deep concavity in its right wall which lies median with the vesicula seminis; it is approximately .18 mm. long and .054 mm. broad in its greatest diameter. The oval vesicula seminis lies to the right side touching the right intestinal cecum, and measures .054 mm. in length and .036 in greatest breadth. The cirrus is well developed and protrusible.

The uterus lies between the mesial neck part of the

ovary and the posterior margin of the anterior testis; it is not distinguishable from the metraterm into which it soon passes. The metraterm is well developed with thick muscular walls, situated to the left side in close contact with the left intestinal cecum, between it on one side and the cirrus sac and the anterior testis on the other, measuring .25 mm. in length and .05 mm. in breadth. Near its terminal end it crosses ventrally the left intestinal cecum to enter the shallow genital atrium. Only the ovum is contained in the uterus or the proximal part of the metraterm. The ovum is contained in the uterus or the proximal part of the metraterm. The ovum is oval in shape and produced into a coiled filament at one end and indistinctly seen elongated filament at the other; measures .09 mm. in length without filaments and .03 mm. in greatest width.

The vitellaria are extensive, situated laterally, overlapping the intestinal ceca and uniting mesially behind the ventral sucker, in the region between it and the genital pore, and in the intracecal field behind the posterior testis to the blind ends of the ceca, leaving entirely free the genital field. They commence at the intestinal bifurcation and terminate a little behind the blind ends of the ceca at about the bifurcation of the short stem of the excretory bladder.

Hosts.- Primary, turtles (Lissemys punctata syn. Emyda granosa); secondary, unknown.

Location.- Ventricle of heart.

Distribution.- Allahabad, India.

HAPALORHYNCHUS INDICUS Thapar, 1933

Synonym.- Tromarhynchus indicus Thapar, 1933

Specific diagnosis.- Hapalorhynchus: The body of the fluke is elongated, cylindrical, and pointed at either end. The length varies from 3.16 mm. to 3.45 mm., and it has its greatest breadth of .35 to .47 mm., at about the level of the posterior testis. The general surface of the body is smooth and does not bear any spines.

The oral sucker is situated at the extreme anterior edge of the body and is extremely protrusible. It is situated at about one-third the distance from the anterior end of the body and has a diameter of .2 mm.

The mouth is in the center of the oral sucker at the anterior end of the body. The excretory pore lies at the posterior extremity, and the genital pore is on the dorsal side behind the position of the acetabulum.

The mouth leads into an elongated straight tube, the esophagus, that extends for about two thirds the distance between the two suckers from the anterior end. It has a cuticular inner lining of its wall. The pharynx is absent, and the esophagus bifurcates in front of the acetabulum into two intestinal ceca that run backward to the posterior end, as slender straight tubes of more or less uniform diameter. Before terminating blindly, at about one-eighth of the body length from the posterior end, the two ceca converge for a short distance.

The excretory pore is terminally situated at the posterior end of the body and leads into a large triangular median collecting sac, the excretory bladder. The excretory bladder extends as far forward as the posterior end of the intestinal ceca, where it divides into two narrow lateral ducts one on either side of the median line. The collecting excretory bladder itself is .2 to .3 mm. long and is a very characteristic feature of the group.

The nervous system is well developed and consists of a distinct esophageal commissure, situated a little in front of the point of bifurcation of the intestinal ceca, at a distance of .45 to .5 mm. from the anterior end of the body. It appears distinctly X-shaped and runs around the esophagus. It further sends a pair of nerves towards the anterior end and a pair towards the posterior end of the body.

The female reproductive organs consist of a single ovary situated between the two testes, on the left side of the median line. It is a tri-lobed organ and leads by a narrow oviduct at about the middle of its right side. The oviduct receives, after a short source, the common duct of the vitelline glands and thus forms an oötype, at the point of its union. Here Laurer's canal also meets and opens on the dorsal surface. The point of union of all these ducts is further marked by the presence of minute unicellular glands.

The vitellaria are very extensive and irregularly scattered throughout the body. They consist of masses of follicles extending on either side of the median line. In front of the acetabulum and behind the posterior testis they form continuous masses filling up all the spaces between the dorsal and ventral walls. In between the acetabulum and the posterior testis they are limited and occupy narrow tracts on either side of the intestinal ceca.

The uterus is very short and arises from the oötype forward. The eggs have not been observed in any of the

specimens obtained so far. There are two testes situated one in front and the other behind the ovary. The testes are divided into a number of distinct lobes that are deeply cleft, showing a varying number of follicles. The posterior testis is the larger of the two and lobulations are very clearly marked.

There is a large seminal vesicle, more or less oval in outline, that lies transversely across in front of the anterior testis and outside the cirrus sac. It is about .2 mm. long and leads into an elongated, pear-shaped cirrus sac in front. This structure is obliquely placed in the body and encloses within it an elongated cirrus. The cirrus, in its proximal portion, is a coiled structure forming as a sort of rudimentary ductus ejaculatorius. The distal partis, however, a straight muscular tube with a slight bend. This is the true cirrus and can be protruded out at the genital pore. Within the cirrus sac there are faint glandular cells that represent the prostate glands.

The genital pore is situated on the dorsal side of the body and is on the left side of the median line.

Host.- Primary, common mud turtle of Northern India (Trionyx gangeticus); secondary, unknown.

Location.- Blood vascular system.

Distribution.- Northern India.

HAPALORHYNCHUS STUNKARDI Byrd, 1939

Specific diagnosis.- Hapalorhynchus: Body delicate, weakly muscular, with rounded to slightly attenuated extremities and almost parallel sides, from 0.72 to 1.44 mm. long by 350 to 420 u wide. Cuticula sparsely beset with hair-like spines. Nerve ring small. Oral sucker protrusible, 80 to 104 u in diameter. Ventral sucker protractile, same size as oral sucker, located from 220 to 360 u behind anterior end of body. Esophagus from 130 to 220 u long, separated into two regions by constriction at about beginning of posterior third, each region dilated, with gland cells. Gland cells form two clusters, one about each dilation, posterior cluster more pronounced. Ceca long, extending to within 110 u of posterior end of body, with irregular course; tending to be turned in toward midline at posterior end; left cecum with prominent loop in region of genital pore. Genital pore dorsal, outside left cecum, just anterior to left testis. Testes two in number; anterior testis transversely oval to triangular in shape, 160 u long by 110

to 170 u wide; posterior testis ddeply notched, lying in midline behind ovary and from 170 to 290 u in front of posterior end of body, from 120 to 220 u long by 140 to 170 u wide. Seminal vesicle large, in intercecal space between acetabulum and anterior testis, mainly outside cirrus sac. Cirrus sac thin walled and nonmuscular, extending from genital pore across body to near right cecum, surrounded by large mass of fairly large prostatic gland cells. Cirrus short, slightly muscular. Ovary irregular in outline, lying close to left cecum, from 200 to 330 u behind acetabulum, measuring 52 to 140 u long by 100 to 130 u wide. Oviduct, ootype, Laurer's canal, small receptaculum seminis, and yolk reservoir present. Vitellaria follicular, from middle of esophagus to excretory bladder, occupying all available space in body except region of acetabulum and genital field. Uterus short, with slightly muscular metraterm, containing single egg. Egg oval, 87 to 95 u long by 48 to 52 u wide, without polar filaments or cornua. Excretory bladder reaching to ends of ceca, transversely looped to give pouched appearance, with slightly muscular wall, giving rise to two lateral collecting tubules. Collecting tubules reaching to oral sucker region, giving rise to capillary tubules which terminate in flame cells.

Hosts.- Primary, turtles (Kinosternon carinatum); secondary, unknown.

Location.- Blood vessels of lung.

Distribution.- U.S.A. (Athens, Georgia).

HAPALORHYNCHUS REELFOOTI Byrd, 1939

Specific diagnosis.- Hapalorhynchus: Body small, from 420 to 550 u long by 120 to 170 u wide, with prominent constriction in region of acetabulum. Integument unarmed. Oral sucker protrusible, 34 to 46 u long by 30 to 42 u wide, half exposed at anterior end of body. Ventral sucker smaller, 17 to 30 u long by 30 to 42 u wide, located about 170 u from anterior end of body. Nerve ring conspicuous, at middle of esophagus, with anterior and posterior nerve trunks. Esophagus about 80 u long, constricted into two regions at nerve ring, with gland cells. Gland cells more compact behind nerve ring. Ceca slender tubes, irregular in width and course, reaching to excretory bladder. Testes two in number, separated by ovary; anterior testis between ovary and cirrus pouch, lying transversely across body with heavy end at right of midline, from 42 to 50 u

long by 108 u wide; posterior testis close behind yolk reservoir, deeply indented, 54 u long by 104 u wide. Seminal vesicle large, lying across body between cirrus sac and acetabulum, mainly outside cirrus sac. Cirrus sac slightly muscular, about 80 u long by 35 u wide, containing small part of seminal vesicle, short ejaculatory duct which terminates in slightly muscular cirrus, and numerous prostatic gland cells. Genital pore dorsal, just inside left cecum, on level with anterior margin of anterior testis. Ovary between testes, transversely elongated mass of cells reaching from cecum to cecum, 16 to 21 u long by 71 to 120 u wide. Oviduct, ootype, seminal receptaculum, Laurer's canal, and shell gland present. Vitellaria follicular, from nerve ring to middle of excretory bladder, occupying all available space in body not occupied by other organs. Uterus short. Metraterm not distinguishable. Ova unobserved. Excretory system essentially like that described for H. stunkardi.

Hosts.- Primary, turtles (Sternotherus odoratus); secondary, unknown.

Location.- Blood vascular system.

Distribution.- U.S.A. (Reelfoot Lake, Tenn.).

HAPALORHYNCHUS EVAGINATUS Byrd, 1939

Specific diagnosis.- Hapalorhynchus: Body small, elongated, slender, tapering toward posterior end where it is almost pointed, from 460 to 950 u long by 110 to 200 u in maximum width. Integument unarmed. Oral sucker terminal, protrusible, from 46 to 60 u in diameter. Ventral sucker a little way behind bifurcation, 38 to 55 u long by 46 to 84 u wide, from 170 to 220 u from anterior end of body. Nerve ring conspicuous, at level of union and second thirds of esophagus, giving rise to anterior and posterior nerve trunks. Esophagus 80 to 190 u long, slender tube through first two-thirds of its length, with prominent dilation in posterior third; posterior dilated part with 10 to 14 conspicuous evaginated pouches that form rosette-like mass around esophagus; pouches may attain measurements of 35 u long by 17 u wide. Esophageal gland cells present, becoming more pronounced in region of esophageal pouches. Ceca slender tubes, with few irregularities, reaching to within 140 u of posterior end of body. Testes two in number, separated by ovary, 130 u behind acetabulum; anterior testis squarish, 42 u in diamter, placed immediately in front of ovary; posterior testis immediately behind ovary, elongated, 97 u long by 42 u wide. Seminal vesicle in midline, curving to left to genital pore, separating anterior testis from acetabulum.

Cirrus sac indistinguishable. Genital pore dorsal, outside of left cecum, at level of anterior margin of anterior testis. Ovary squarish, close between testes, 21 to 30 u long by 42 to 60 u wide. Genital complex unobserved. Vitellaria follicular, from pouched portion of esophagus to excretory bladder, extensive. Uterus short. Metraterm indistinguishable. Ova unobserved. Excretory vesicle tubular, slightly coiled, reaching to posterior limits of vitellaria, almost to ends of ceca.

Hosts.- Primary, turtles (Amyda spinifera); secondary, unknown.

Location.- Mesenteric blood vessels.

Distribution.- U.S.A. (Reelfoot Lake, Tenn.).

Genus UNICAECUM Stunkard, 1925

Generic diagnosis.- Spirorchinae: Medium-sized monostomate blood flukes with tapering extremities and smooth integument. Esophagus long, sinuous, with few gland cells that become more compact about posterior end of esophagus. Nerve ring inconspicuous. Intestinal tract with single cecum; cecum large, reaching to posterior end of body. Single spirally coiled testis, in central three-fifths of body. Vesicula seminalis spirally coiled, originating from anterior end of testis in U. ruszkowskii, posterior end of testis in U. dissimilis, two-thirds as long as or as long as testis. Cirrus sac short, slightly muscular. Genital pore ventral, close behind testis. Ovary tubular or with prominent lobes, arising from an otherwise tubular structure, mostly posterior to and dorsal to testis, with anterior end overlapping posterior end of testis. Oviduct, shell gland, and receptaculum seminis present. Uterus with spherical dilation or posterior tubular extension. Metraterm short, slightly muscular. Vitellaria follicular, just under cuticle, from esophagus to posterior end of body. Excretory bladder short. Parasites in blood steam of turtles.

UNICAECUM RUSZKOWSKII Stunkard, 1925

Specific diagnosis.- Unicaecum: 6 to 8 mm. long, 0.5 to 0.96 mm. in width, and 0.2 to 0.4 mm. in thickness. The musculature is weak; acetabulum and pharynx absent. Esophagus surrounded by secretive cells. Digestive system consists of a single cecum, which extends almost to posterior end of body. Testes form continuous lobed columns

center of body; vas deferens arises from anterior end and passes backward in sinuous course. Cirrus sac and cirrus present. Genital pore ventral, sinistral, near posterior level of testis. Ovary long, coiled, situated in posterior third of body; oviduct arises from posterior end, passes backward to oötype, and uterine duct leads forward to genital pore. Seminal receptacle and Laurer's canal absent. Vitellaria consist of irregularly distributed follicles extending from level of esophagus to oötype. Eggs large, thin-shelled, spherical, discharged singly.

Hosts.- Primary, turtles (Pseudemys scripta, and Bryd[2] identified specimens from Pseudemys troosti and Graptemys pseudogeographica pseudogeographica); secondary, unknown.

Location.- Large arteries about heart.

Distribution.- Southeastern United States and Reelfoot Lake, Tenn.

UNICAECUM DISSIMILIS Byrd, 1939

Specific diagnosis.- Unicaecum: Body elongated, tapering at both ends, 3.03 mm. in length by 374 u in maximum width. Integument unarmed. Oral sucker subterminal, protrusible, 104 u long by 95 u wide. Esophagus slightly muscular, almost straight tube, approximately 390 u long by 45 u in widest place. Esophageal gland cells present, becoming more pronounced toward posterior part of esophagus. Nerve ring inconspicuous. Cecum with prominent lobes at point of origin, undulating gently in passing to posterior end of body. Single spirally coiled testis, ventral to cecum, extending to within 780 u of posterior end of body, approximately 1.70 mm. long. Seminal vesicle long, much dilated tube extending through two-thirds length of testis. Vas deferens arising from posterior end of testis. Cirrus sac short, receiving duct from vesicula seminalis which originates close beside entrance of vas deferens, containing small pars prostatica with numerous gland cells, and short ejaculatory duct which ends in slightly muscular cirrus.

[2] Byrd's (1939) material differed from that described by Stunkard in that none of the material ever attained a length of 4 mm., and there is considerable less coiling of the ovary. He was only able to trace the coiled seminal vesicula four-fifths the distance between the genital pore and entrance of the esophagus into the cecum. Other than this the striking similarities between Byrd's and Stunkard's material justifies their assigning it to the species U. ruszkowskii.

Genital pore ventral, approximately 700 u in front of posterior end of body; common genital sinus present, male and female ducts merging before passing to outside. Ovary tubular, loosely coiled, giving rise to two short lobes from middle of long axis (giving ovary roughly an H-shaped appearance), lying dorsal to cecum, beginning 208 u in front of posterior end of testis, ending about 430 u behind end of testis, approximately 640 u long. Oviduct arising from posterior end of short caudal lobe of ovary, passing immediately into oötype which is surrounded by shell gland. Laurer's canal present. Receptaculum seminis absent. Uterus with large median pouch that extends posteriorly to very near end of cecum. Metraterm short, weakly muscular. Egg unobserved. Vitellaria follicular, extensive, from mid-region of esophagus to end of cecum, just under body surface, completely enveloping body within limits. Excretory bladder short, tube-like, reaching to near end of cecum before giving rise to lateral collecting tubules.

Hosts.- Primary, turtles (Pseudemys troosti); secondary, unknown.

Location.- Blood vessels about heart.

Distribution.- U.S.A. (Reelfoot Lake, Tenn.).

Genus VASOTREMA Stunkard, 1926

Generic diagnosis.- Spirorchinae: Small distomate blood flukes with rounded to pointed extremities and smooth integument. Suckers protrusible. Esophagus long, with dilations, with or without evaginations in posterior part, with gland cells that may or may not show concentrations around posterior half of esophagus. Ceca simple, reaching to very near posterior end of body. Nerve ring prominent, about one-third length of esophagus from oral sucker, giving rise to longitudinal nerve trunks. Testis simple, much coiled to almost straight, placed immediately behind ovary, mostly in posterior half of body. Seminal vesicle bag-like to tubular, extending from testis to intercecal area in front of ovary. Cirrus sac small, slightly muscular, usually lying transversely across body in region of genital pore containing small portion of seminal vesicle, numerous prostatic gland cells, short ejaculatory duct, and short cirrus. Genital pore ventral, over or just to one side of left cecum, between level of acetabulum and ovary. Ovary near middle of body, alternating from right to left side of midline. Oviduct, Laurer's canal, receptaculum seminalis, and yolk reservoir usually present. Vitellaria follicular, confined to region between acetabulum and ends of ceca, may or may not overlap in intercecal

area. Uterus short, with muscular metraterm. Ova elongated to spherical, large. Miricidia with pigmented eyespots. Excretory bladder short, typical for subfamily. Parasitic in blood vascular system of soft-shelled turtles.

VASOTREMA AMYDAE Stunkard, 1926

Specific diagnosis.- Vasotrema: Ten times as long as wide; the sides of the body are parallel over a great length and the extremities are rounded. The body narrows in back of the digestive cecum. In cross-section it is oval, being more or less flattened. The mounted specimens measure 1 to 1.32 mm. long, .093 to .142 mm. wide, and .96 to .08 mm. in thickness. The musculature is delicate and the suckers are relatively small. The acetabulum is slightly protractile but sessile, and is situated at the level of the union of the anterior quarter and the three posterior parts of the body. It is spherical or ovoid and measures .045 to .055 mm. in diameter.

The esophagean nerve ring is visible in cross-section and is situated at a third or a quarter of the distance which separates the oral sucker from the bifurcation of the digestive tube. From this ring the nerves leave both forwardly and to the rear but their number and their path havn't been determined exactly.

The oral sucker is spherical, ovoid, or pyriform and having the same dimensions as the acetabulum measuring from .04 to .055 mm. in diameter. It is slightly protractile, a little longer than wide when it is extended. No pharynx. The esophagus extends from the oral sucker to the bifurcation of the digestive tube, a little in front of the acetabulum and presents at the level of its posterior quarter a series of great diverticula bordered by a cuticle which continues with that of the esophagus. These appendages are found in Spirorchis in the same place, but they are much smaller. It is then more probable that the little sac described in Spirorchis represent the initial stage in the development of these great diverticula. It is probable that these organs do not serve simply to contain the alimentary reserves, a role which couldn't be explained among the Sanguinicola trematodes, but that they have a digestive function. They take birth on a very short segment of the esophagus, passing back and forth or toward the wall of the body. They extend backwards to the bifurcation of the digestive tube and forward an equal length. The esophagus is surrounded by secretory cells. The esophageal portion ~~in~~ back of the birth of the diverticula is frequently

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dilated. The ceca end in a sac at the level of the union of the posterior sixth and the anterior 5/6ths of the body. The digestive epithelium is formed of flattened cells the nuclei of which project into the lumen of the conduits.

The post-cecal portion of the body contains a lymphatic vesicle, a sort of spiraled tube closed at both ends, which shows in cross-section the presence of a liquid holding in suspension cells and little eosinophile granules and this histologic aspect is the same as that of the lymphatic vesicle of Amphistomes.

The excretory system was impossible to study among the dead animals and consequently it hasn't been possible to follow the path of the tubules and to determine the function of the flame cells. The excretory pore is terminal, vesicle short and soon divides into two collecting canals passing forward on each side of the body. These canals are very small, generally flattened and rarely visible in cross-section; their caudal extremity is somewhat dilated and pear-shaped.

Testis a spiraled organ extending longitudinally between the digestive ceca. Its anterior end is situated a little forward of the middle of the body, the posterior end a little forward of the caudal end of the ceca. The vas deferens springs from near its anterior end and goes forward. At the level of the ovary it opens into a large seminal vesicle which occupies almost the entire space between the ceca, the ovary, and cirrus pouch. The seminal vesicle connects with this pouch and extends obliquely forward to issue at the genital pore. It measures from .019 to .029 mm. in diameter and its length varies according to its degree of contraction. There exist numerous cells between the wall of the sac and the ejaculatory canal but they don't seem to be secretory. The genital pore, ventral and lateral, is situated below the left cecum at .02 mm. of the acetabulum. The orifice of the cirrus pouch is median and anterior to the orifice of the metratern.

The female organs are simple. The ovary is most frequently to the left, sometimes to the right of the median plane, at the level of the union of the forward three-fifths and the posterior two-fifths of the body; spherical or ovoid, its dorso-ventral axis being more elongated and measuring from .036 to .06 mm. in diameter. The oviduct arises on its postero-lateral edge; it is first latero-ventral and directed toward the rear, then becomes dorsal and medial and in this portion it is widened and filled with spermatozoa, the receptaculum seminis. The distal part of the widened portion becomes ventral and gives rise to Laurer's canal which is directed first ventrally

then postero-dorsally and opens upon the dorso-median line immediately forward of the anterior end of the testis. After the emergence of Laurer's canal the female genital conduit receives the common vitelline canal, passes forward along and in the middle of the dorsal face of the ovary and is directed in a straight line toward the genital pore. This portion where the egg is formed functions as the oötype and uterus. Since the barely formed egg is at once cast off this organ is rather an oötype. The oötype of Vasotrema extends from the region posterior to the ovary to the metraterm. The terminal portion of the oötype is dorsal with reference to the cirrus pouch, and the sphincter of the metraterm is feeble. The eggs are enormous for so small a worm. The vitellaria consist of little follicles desseminated along the length of the ceca; they are not formed of separate lobes; they extend to the caudal extremity of the ceca and end slightly forward of the ovary. Among some specimens they go to the level of the bifurcation of the digestive tube. On each side two short vitelline canals pass behind the ovary and join on the median line to form a little vitelline receptacle which empties into the oötype.

Eggs large, oval, varying in size, thin-shelled. Miracidia oval having pointed ends, circular in cross-section. Anterior end with papilla without cilia from bases of which arise two cephalic glands. Eyespots visible. The four flame cells and two excretory pores occupy the usual positions.

Hosts.- Primary, turtles (Amyda spinifera, Amyda ferox); secondary, unknown.

Location.- Vascular blood system.

Distribution.- U.S.A. (Florida, Indiana.)

VASOTREMA ATTENUATUM Stunkard, 1928

Specific diagnosis.- Vasotrema: Similar to Vasotrema amydae. Body generally longer and thinner. Mounted specimens 1.4 to 1.76 mm. long; 0.08 to 0.13 mm. in width; 0.06 to 0.08 mm. in thickness. Acetabulum somewhat smaller and closer to anterior end, 0.038 to 0.048 mm. in diameter, and is situated at 2/7ths of the length of the body. The nervous, excretory, and lymphatic systems do not differ from those of V. amydae.

The oral sucker is small, elongated, oval or pyriform, and measures .033-.048 mm. in length and .028 to .033 mm. in width. The esophagus is relatively shorter and the

diverticula are shorter than in Spirorchis.

The point of the bifurcation of the digestive tube is situated much further forward, and the ceca are much longer than among V. amydae. It is the genital areas that differ most. The testis of V. attenuatum is much larger and more elongated. Vas deferens directed toward the rear from its beginning to the anterior end of the testis and spreads to form a large seminal vesicle which covers that extremity and extends forward as far as the oötype. The vesicle is to the rear of the ovary and not anterior as in V. amydae; it continues forward by a little canal which passes forward of the cirrus pouch then is directed toward the rear and enters a quite characteristic, and of problematical significance, sac-shaped organ. From there it is directed posteriorly then anteriorly to enter the cirrus. The copulatory organs are identical to those of V. amydae. The sac-shaped organ crossed by the spermatic conduit occupies the same position as the seminal vesicle of V. amydae. It has a fibro-membranous wall and is filled with large cells. The wall of the spermatic canal is continuous during the crossing of the sac-like organ and is without connection with the surrounding non-secretory cells which have a thick membrane and appear empty. The spermatic conduit doesn't extend to the rear more than half the length of the sac and has no connection with the posterior cells. One may suppose that this organ represents a prostate in spite of the appearance of the cells and the absence of communication with the spermatic canal or that it serves as a sustaining organ, but from this point of view it doesn't appear necessary. Moreover the oötype is situated parallel to the sac which occupies the greater part of the body; there doesn't seem, therefore, to be room for the formation of the egg. One may admit that if the sac were to be transformed into a seminal vesicle by a disintegration of the cells which fill it and if the wall of the spermatic canal disappeared one would find the same structure among V. amydae. But this hypothesis is scarcely admissable since we have to deal with sexually mature worms.

The ovary is situated on the right side at the level of the anterior and middle third of the body immediately behind the sac which surrounds the terminal portion of the spermatic canal. The distance which separates the ovary and testicle is twice greater than among V. amydae. The connections of the oviduct, of the fertilization chamber, of Laurer's canal, and of the oötype are similar in the two species. Among V. attenuatum, however, the transverse vitelline canals are at the level of the anterior end of the testicle and at 9 mm. behind the ovary. The union of the vitelline canals give rise to a large common canal or receptacle

which passes forward beside or above the seminal vesicle from the testicle to the ovary. These two organs, at this level, fill the space between the ceca.

Eggs are found in all tissues and organs. Are evacuated in feces. Are large, oval, thin-shelled, and of various sizes becoming brown and spherical as they age; .09 to .175 mm. long by .07 to .095 mm. wide. The miracidium shell is thin and transparent. Miracidia oval, pointed ends, circular in cross-section. At the anterior end are papilla without cilia from the base of which issue two cephalic glands. The eyespots are visible. The four flame cells and the two excretory pores occupy the usual positions. The operculum is .042 mm. in diameter.

Hosts.- Primary, turtles (Amyda spinifera, Amyda ferox); secondary, unknown.

Location.- Vascular system

Distribution.- U.S.A. (Florida, Indiana).

VASOTREMA ROBUSTUM Stunkard, 1928

Specific diagnosis.- Vasotrema: Differs from Vasotrema amydae and V. attenuatum in being larger, having a greater development of the vitellaria, the genital pore being situated at the level of the ovary, and the suckers being much larger.

Measure 1.4 to 3 mm. in length; .24 to .36 mm. in width; .08 to .14 mm. in thickness. Musculature more robust, especially as regards the acetabulum which is .12 to .19 mm. in diameter and located at the union of the forward and middle third of the body.

The nervous, excretory, and lymphatic systems are similar to those of V. amydae.

The oral sucker is spherical or ovoid or pyriform, measures .075 to .11 mm. in diameter. No pharynx. Esophagus has diverticula whose size is intermediary between V. amydae and V. attenuatum. Ceca extend almost to posterior end of body. The post-cecal region contains a coiled lymphatic vesicle.

Testis voluminous, spiral-shaped, located in intercecal area in posterior half of body. Distance between caudal end of testis and extremity of ceca is three times greater than length of post-cecal region. Anteriorly the testis extends as far as region of ootype; vas deferens arises here passing forward under median part of ovary. Forward to ovary conduit enlarges to form seminal vesicle then turns toward the right and becomes dorsal, goes forward again, turns to left and comes back penetrating into

cirrus pouch. The seminal vesicle thus forms a loop forward of the ovary and when full of sperm it crowds the neighboring organs and covers them partially. The cirrus pouch is directed post laterally and ventrally to issue at genital pore situated at level of ovary under the left cecum. Pouch pyriform, slightly curved, measures .028 to .038 mm. in diameter. Length double or triple its width.

Ovary spherical or ovoid with a large transversal axis, measures .08 to .13 mm. in diameter; situated on right side of middle of body. Oviduct springs from its right posterolateral edge, passes posteriorly and becomes ventral, returns to dorsal side and dilates into a large receptacle filled with spermatozoa. The terminal portion of the spermatozoa receptacle becomes ventral and gives rise to Laurer's canal which on the ventral side goes posteriorly then becomes dorsal to open upon the median line or close to the level of the anterior edge of the testicle. The female canal then receives the common vitelline duct, dilates to form the oötype which passes on the left side of the body. One specimen had an egg in the oötype, but the envelope had collapsed making it impossible to get dimensions. The wall of the oötype is thin with no Mehlis' glands observed. Region comprised between the dilated portion filled with spermatozoa, the oviduct, and the oötype containing numerous non-glandular but rather mesenchymatic cells. The metraterm is rather long; its wall contains circular and longitudinal muscular fibers. Vitellaria consist of little follicles which extend from the terminal extremity of the ceca to the level of the acetabulum. Behind the testicles and in front of the seminal vesicle the intercecal region is filled with vitelline follicles. The vitelline ducts pass transversely along the median line to the level of the anterior margin of the testicle and unite to form the vitelline receptacle which empties into the oötype.

Eggs large, oval, and varying in size. Miracidia oval, having pointed ends, and circular in cross-section. Anterior end with papilla without cillia from the base of which arise two cephalic glands. Eyespots visible. The four flame cells and the two excretory pore occupy the usual positions.

Host.- Primary, turtles (Amyda spinifera); secondary, unknown.

Location.- Arterial system.

Distribution.- U.S.A. (Florida, Indiana, Tenn.)

VASOTREMA LONGITESTIS Byrd, 1939

Specific diagnosis.- Vasotrema: Body small, almost

oval in outline, from 590 to 730 u long by 190 to 300 u wide. Integument unarmed. Oral sucker terminal, protrusible, from 30 to 50 u in diameter. Ventral sucker protrusible, bell-shaped, from 34 to 71 u in diameter, located from 100 to 130 u behind anterior end of body, close behind bifurcation of ceca. Esophagus from 50 to 70 u long, usually with two dilations in posterior half, surrounded by gland cells. Gland cells more compact around dilated part of esophagus. Nerve ring conspicuous, around anterior end of esophagus. Ceca simple, with few irregularities in outline or course, extending to excretory vesicle. Testis occupying intercecal space behind ovary, approximately 270 u long by 200 u wide, with 15 to 17 transverse loops across body between ceca, beginning slightly in advance of body middle, ending very near ends of ceca. Vas deferens arising from anterior end of testis, soon expanding into thin walled tube-like vesicula seminalis. Vesicula seminalis loosely coiled, passing around left side of ovary to right side of midline near level of acetabulum where it joins the cirrus sac. Cirrus sac well developed, slightly muscular, containing small portion of seminal vesicle, numerous prostatic gland cells, ejaculatory duct, and short cirrus, lying almost transversely across body close behind acetabulum. Genital pore ventral, outside left cecum about on level with caudal boundary of acetabulum. Ovary small, from 30 to 40 u long by 50 to 65 u wide, located to right of midline from 55 to 70 u behind acetabulum. Receptaculum seminis, ootype, shell gland, Laurer's canal, and yolk reservoir present. Vitellaria follicular, mainly along ceca, from equatorial plane of acetabulum to midway between end of testis and ends of ceca, filling intercecal area between acetabulum and testis. Uterus slender tube. Metraterm muscular, short. Ova elongated, with narrow, tube-like end at one extremity, other end rounded, from 108 to 130 u long by 45 u wide; single ovum contained in uterus. Miracidia with eyespots. Excretory bladder short, reaching only to ends of ceca, about 40 u long.

Hots.- Primary, turtles (Amyda spinifera); secondary, unknown.

Location.- Arterial circulation.

Distribution.- U.S.A. (Reelfoot Lake, Tenn.).

Genus NEOSPIRORCHIS Price, 1932

Generic diagnosis.- Spirorchinae: Body greatly elongated, threadlike, subcylindrical. Cuticula provided with

fine transverse ridges but without spines. Oral sucker moderately developed; acetabulum absent. Esophagus, especially the posterior half, surrounded by unicellular glands; intestinal tract similar to that of schistosomes. Genital aperture lateral, in posterior half of body. Testis slender, more or less spiral, extending to intestinal union; vas deferens arising from posterior pole of testis; cirrus pouch present. Ovary slender, spiral, situated along posterior postion of testis. Seminal receptacle and Laurer's canal absent. Vitellaria extending from intestinal bifurcation to near level of genital aperture. Eggs without polar processes. Parasitic in marine turtles.

NEOSPIRORCHIS SCHISTOSOMATOIDES Price, 1932

Specific diagnosis.- Neospirorchis: Body threadlike, 7.45 to 9.5 mm. long by 140 to 220 u wide; pretesticular portion of body slightly flattened dorso-ventrally. Posttesticular portion cylindrical or subcylindrical. Cuticula without spines but with fine transverse ridges. Oral sucker subterminal, 32 to 40 u in diameter; acetabulum absent. Esophagus 595 to 680 u long, consisting of two parts about equal in length; anterior part slender, posterior part about twice the width of anterior part and surrounded by unicellular glands. Intestinal branches slightly sinuous, uniting near level of anterior pole of testis, forming a common cecum terminating near posterior end of body. Excretory pore terminal; excretory vesicle Y-shaped. Genital aperture lateral, about 1 to 1.2 mm. from posterior end of body. Cirrus pouch weakly developed, enclosing a long slender, muscular cirrus; cirrus apparently protrusible, but not actually protruded in any of the specimens available. Vas deferens relatively long and convoluted, arising from posterior pole of testis. Testis long, slender, more or less spiral, and extending anteriorly as far as level of intestinal union. Ovary long, slender, more or less spiral, and extending anteriorly from a point posterior to genital aperture for about one-third the length of the testis. Oviduct slender, extending posterior to an oötype about 500 u from posterior end of body; oviduct joined here by vitelline duct and continued anteriorl as a slender tube expanding to form the uterus. Seminal receptacle and Laurer's canal absent. Vitellaria well developed, extending into intercecal field from posterior end of esophagus to intestinal union thence continuing dorsal to common cecum and terminating near level of genital aperture. Vitelline duct single, extending posteriorly to oötype and expanding there to form a large vitelline reservoir.—Uterus slightly tortuous,

containing 7 to 15 eggs, extending anterior to genital aperture, then turning posteriorly. Eggs oval, 44 u long by 32 u wide, without polar prolongations.

Hosts.- Primary, turtles (Chelone mydas); secondary, unknown.

Location.- Visceral blood vessels.

Distribution.- U.S.A. (Washington, D.C.).

Genus AMPHIORCHIS Price, 1934

Generic diagnosis.- Spirorchinae: Body slender, subcylindrical. Cuticula marked with fine transverse ridges. Oral sucker and acetabulum present. Esophagus slender, surrounded by unicellular glands; intestinal ceca slender not uniting posteriorly. Cirrus pouch well developed, containing a short cirrus, internal seminal vesicle, and prostate cells; external seminal vesicle anterior to cirrus pouch. Testes two in number, one anterior and the other posterior to cirrus pouch and ovary. Seminal receptacle and Laurer's canal present. Vitellaria consisting of two groups of follicles, one group extending from intestinal bifurcation to anterior testis, and the other from posterior end of vitelline reservoir to near posterior end of body. Parasitic in blood vessels of marine turtles.

AMPHIORCHIS AMPHIORCHIS Price, 1934

Specific diagnosis.- Amphiorchis: Body elongated, 1.87 to 2.2 mm. long by 120 to 148 u wide at level of posterior testis, oval to subcylindrical on cross section. Cuticula without spines but marked by fine transverse striations. Oral sucker subterminal, 40 to 44 u in diameter; acetabulum circular 40 to 64 u in diameter, 476 to 510 u from anterior end of body. Esophagus 255 to 320 u long, surrounded by unicellular glands; intestinal ceca slender, terminating blindly about 280 u from posterior end of body. Excretory pore terminal; excretory vesicle Y-shaped, the branches slightly longer than the stem. Genital aperture median, immediately anterior to ovary. Cirrus pouch oval, 60 to 80 u long by 48 to 60 u wide, enclosing a short, thick cirrus, a moderately large internal seminal vesicle, and numerous prostate cells; external seminal vesicle more or less globular, 40 to 60 u in diameter, immediately anterior to and slightly to right of cirrus pouch. Anterior testis oval, 100 to 120 u long by 80 to 88 u wide, in front of external seminal vesicle; posterior testis oval, 140 to 190 u long by 100 to 120 u wide, situated a short distance

caudal to posterior end of vitelline reservoir and separated from it by a band of vitelline follicles. Ovary irregularly oval, 120 to 140 u long by 54 to 80 u wide, between testes and immediately posterior to cirrus pouch. Seminal vesicle globular, 24 to 40 u in diameter, posterior to ovary and situated in curve of vitelline reservoir. Mehlis' gland present, consisting of relatively few large cells. Laurer's canal relatively large, opening in mid-dorsal line a short distance posterior to seminal receptacle. Vitelline reservoir large and curved. Vitellaria consisting of two groups of follicles, one group between intestinal bifurcation and anterior testis, and the other between posterior end of vitelline reservoir and posterior end of body. Metraterm simple, muscular. Eggs not observed.

Hosts.- Primary, turtles (Chelone mydas); secondary, unknown.

Location.- Visceral blood vessels.

Distribution.- U.S.A. (Washington, D.C.).

Genus LEAREDIUS Price, 1934

Generic diagnosis.- Spirorchinae: Body elongate, slightly constricted equatorially, flattened dorso-ventrally. Oral sucker and acetabulum present. Esophagus long and surrounded by unicellular glands; intestinal ceca slender, not uniting posteriorly. Genital aperture median or slightly to left, near posterior end of body. Cirrus pouch present, largely filled by internal seminal vesicle; external seminal vesicle present. Testes numerous, preovarial. Ovary deeply lobed, post-testicular. Laurer's canal present. Eggs with polar prolongations. Parasitic in circulatory system of marine turtles.

LEAREDIUS LEAREDI Price, 1934

Specific diagnosis.- Learedius: Body elongated, 3.4 mm. long by 690 u wide, slightly constricted near equator of body, flattened dorso-ventrally. Cuticula with verrucae similar to, but smaller than, those of species of Schistosoma. Oral sucker cup-shaped, 280 u long by 240 u wide, oral aperture subterminal; acetabulum circular, 340 u in diameter, pedunculated, near equator of body. Esophagus slightly tortuous, 1.02 mm. long, surrounded by unicellular glands. Intestinal ceca slender, curving inward at level of acetabulum, terminating near posterior end of body. Excretory pore terminal, excretory vesicle Y-shaped, the

branches of about the same length as stem. Genital aperture about 360 u from posterior end of body, slightly left of median line. Cirrus pouch shaped somewhat like an elongated letter S, its base enlarged and lying about 360 u from genital aperture, containing a single internal seminal vesicle, numerous prostate cells, and a protrusible cirrus; external seminal vesicle transversely elongate, 144 u long by 60 u wide, to right of base of cirrus pouch. Testes 28 in number in intercecal field between external seminal vesicle and acetabulum. Ovary deeply lobed, more or less dendritic, 240 u long by 340 u wide, posterior to external seminal vesicle. Ovudict long and slender, arising at right side of ovary and expanding posteriorly to form an elongated oötype; seminal vesicle postero-dorsal of oötype; Laurer's canal slender opening in mid-dorsal line near level of ends of ceca. Vitelline reservoir large, anterior to oötype. Vitellaria consisting of small follicles forming a transverse bend across body between intestinal bifurcation and level of posterior margin of acetabulum then extending posteriorly in extracecal fields to level of tips of ceca. Metraterm short and containing a single egg. Egg fusiform, about 210 u long (including polar prolongations) by 28 u wide.

Hosts.- Primary, turtles (Chelone mydas); secondary, unknown.

Location.- Circulatory system.

Distribution.-U.S.A. (Washington, D.C.).

LEAREDIUS SIMILIS Price, 1934

Specific diagnosis.- Learedius: Body elongated, 2.2 mm. long by 320 u wide, slightly constricted at level of acetabulum. Cuticula with verrucae, larger and more numerous than those of L. learedi. Oral sucker subterminal, 160 u in diameter; acetabulum cercular, 340 u in diameter, pedunculated, about 750 u from anterior end of body. Esophagus about 170 u long, surrounded by unicellular glands; intestinal ceca slender, extending to near posterior end of body. Excretory pore terminal; excretory vesicle Y-shaped, the limbs longer than stem. Genital aperture almost median, 260 u from posterior end of body. Cirrus pouch somewhat S-shaped, its base about 1 mm. from genital aperture, almost completely filled by internal seminal vesicle; external seminal vesicle 180 u long by 80 u wide, situated as in L. learedi. Testes arranted as in L. learedi, the exact number not ascertainable in the specimen available. Ovary lobulated, 260 u long by 120 u wide, between external seminal vesicle

and vitelline reservoir, ventral to cirrus pouch. Oviduct dilated, arising from right side of ovary; oötype short and surrounded by Mehlis' gland; seminal receptacle present; Laurer's canal not observed. Vitellaria extending from level of intestinal bifurcation to about middle of ovary and occupying entire intercecal field anterior to testes. Egg fusiform, 234 u long (including polar prolongations) by about 12 u wide.

Hosts.- Primary, turtles (Chelone mydas); secondary, unknown.

Location.- Circulatory system.

Distribution.- U.S.A. (Washington, D. C.).

PART III

SYNOPSIS OF THE FAMILY SCHISTOSOMIDAE

The family Schistosomidae is composed of a number of genera of trematodes parasitic in the blood-vascular system of warm-blooded vertebrates. They differ essentially from all other trematodes in that the sexes are separate, with striking sexual dimorphism; the eggs are not operculate; and the cercariae (excluding those of the related families Aporocotilidae and Spirorchidae) are of the fork-tailed type which actively penetrate into the host through the skin. They inhabit the venous system of mammals and birds in various tropical and subtropical countries.

The blood flukes of the family Schistosomidae are perhaps the most important trematodes parasitic in men; they cause diseases known as bilharziasis, endemic hematuria or urinary schistosomiasis, and intestinal schistosomiasis, also known as katayama or schistosomiasis of the Far East. Several species are of considerable veterinary importance, several species occurring in ruminants and other domesticated animals. The manner in which the free-swimming larval forms gain access to the body of the definitive host (skin penetration by the cercaria) is correlated with the fact that many of the species are parasitic in aquatic

birds, as these birds are naturally exposed to attack in cercaria-infested water.

In 1929 Emmett W. Price prepared a synopsis of the family Schistosomidae, but since the time of this publication there have been many new forms discovered and described. The writer has, therefore, attempted to assemble descriptions of all genera and species known, building an up-to-date synopsis.

Family SCHISTOSOMIDAE Looss, 1899

Synonym.- Schistosomatidae Poche, 1907; Bilharziidae Odhner, 1912.

Family diagnosis.- Trematoda: Sexes separate; pharynx absent; esophagus short, terminating posteriorly in a bifurcation to form intestinal branches of ceca which join caudally at the cecal union to form a single, slender intestinal cecum terminating near the posterior end of the body. Suckers present or absent; acetabulum, when present, cephalad of the genital pore. Body of male may be widened caudad of the acetabulum and have the side incurved ventrally, forming a gynaecophoric canal in which the female lies. Testes consist of four or more follicles. Cirrus pouch present or absent. Female more slender than male. Ovary elongate, sometimes spirally curved, and lying cephalad of the cecal union. Laurer's canal present or absent. Vitellaria extensive, extending from the distal pole of the ovary to the posterior end of the body. Parasitic in the blood vessels of birds and mammals.

Subfamily SCHISTOSOMINAE Stiles and Hassall, 1898

Synonym.- Schistosomatinae Stiles and Hassall, 1926

Subfamily diagnosis.- Schistosomidae: Males flattened and with the lateral edges of the body infolded ventrally to form a gynaecophoric canal. Suckers present. Intestinal ceca long, usually uniting caudad of the equator

of the body: common cecum relatively short. Testes situated in the anterior or posterior half of the body, always cephalad of the cecal union. Females slender, threadlike, either longer or shorter than males. Uterus usually contains some eggs.

Genus SCHISTOSTOMA Weinland, 1858

Synonym.- Gynoecophorus, Diesing, 1858; Bilharzia, Gobbold, 1859; Theosoma, Moquin-Tandon, 1860.

Generic Diagnosis.- Schistosominae: Preacetabular portion of male short, cylindrical or nearly so; postacetabular portion widened and with edges inrolled ventrally forming a gynaecophoric canal. Cirrus pouch absent. Seminal vesicle present, pretesticular. Testes few in number (less than 10) situated at the beginning of the gynaecophoric canal. Female filiform, larger than male. Ovary elongated in median line, usually cauded, rarely cephalad, on equator of body. Laurer's canal absent. Eggs oval, or spindle shaped, not operculated, with terminal or lateral spine, or with a rudimentary lateral spine, and ultimately containing a ciliated miracidium. Parasitic in the blood vessels of mammals.

Larva a furcocercous, apharyngeal, spinose cercaria without eyespots; with paired group of penetration glands around the acetabulum; penetration gland ducts opening at the anterior end of the oral sucker and capped by hollow piercing spines; escretory system consisting of four or five pairs of flame cells one pair of which is located in the base of the tail stem. Larval stages in snails.

SCHISTOSOMA HAEMATOBIUM (Bilharz, 1852) Weinland, 1858

Synonyms.- Distoma haematobium Bilharz, 1852; Gynaecophorus haematobius (Bilharz, 1852) Gobbold, 1859; Bilharzia magna Cobbold, 1859; Theeosoma haematobium (Bilharz, 1852) Moq.- Tanbon, 1860; Bilharzia capensis Harley, 1864; Gynaecophorus magnus (Cobbold, 1859) Stossich, 1892; Bilharzia haematobia hominis Kowaleski, 1895; Bilharzia haematobia magna (Cobbold, 1859) Kowalewski, 1895; Bilharzia aegtiacae Miyagawa, 1924.

Specific Diagnosis.- Schistosoma: Male 4 to 15 mm. long by about 1 mm. wide. Anterior part of body short, subcylindrical; posterior part long, flattened, and with lateral edges infolded ventrally, forming the gynaecophoric canal. Cuticle tuberculate and spiny. Oral sucker subterminal, elongated antero-posteriorly, and lined with fine

spines; acetabulum circular, pedunculated, apiny, and situated a short distance caudad of oral sucker. Esophagus short and surrounded by esophageal glands; immediately in front of acetabulum the esophagus bifurcates to form the paired intestinal ceca, the two branches extending caudad to about the equator of the body, where they unite to form a common cecum, which terminates near the posterior end of the body. Testes 4 to 5 in number, situated dorsally near the beginning of the gynaecophoric canal. Seminal vesicle spherical situated in front of the anterior testis. The genital pore opens in the median line at the beginning of the gynaecophoric canal.

Female about 20 mm. long, filiform, and with a maximum width of 250 u. Cuticle without spines, except in suckers, and at posterior end of body. Digestive tract similar to that of male. Ovary elongate, in posterior half of body, and cephalad of cecal union. Uterus long, ending posteriorly in a bulblike oötype, immediately posterior of which the shell gland, oviduct and vitelline duct unite. Vitellaria composed of transversely elongated follicles situated on each side of the common cecum, extending from the cecal union to the posterior end of the body. Egg oval, 120 u. to 160 u. long by 40 u. to 60 u. wide, provided with a terminal spine.

Cercaria furcocercous, apharyngeal, spinose. Body, according to Faust (1926), 140 u. to 240 u long by 57 u to 100 u wide; tail stem 175 u to 250 u long by 35 u to 50 u wide; furcal rami 60 u to 100 u long. Oral sucker 64 u long by 60 u wide, acetabulum small. Penetration glands consist of two pairs of large nucleated cells with granular acidophilic cytoplasm and three pairs with basophilic cytoplasm. Penetration gland ducts moderately thick opening at the anterior end of oral sucker and capped by five pairs of hollow piercing spines. The germ cells lie caudad to acetabulum and consist of several large cells. The excretory system pattern consists of three paies of flame cells in the body and one pair in the tail stem.

Hosts.- Primary, man, monkey, and, experimentally, rats and mice; secondary, snails (Bulinus contorus, B. dybowski and B. innesi in Egypt; B. brochii in Tunis; Physopsis Africana in Belgian Congo, Natal, and Transvaal; P. nasuta and Lymnaea natalensis in S. Africa; Planorbis dufourii in Portugal).

Location.- Portal and mesenteric veins, and veins of bladder.

Distribution.- Africa, Australia, Asia (Arabia,

Cypress, India, Mesopotamia, Palestine, and Persia), and Europe. (Greece and Portugal).

SCHISTOSOMA HAEMATOBIUM var. INTERCALATUM (Fisher, 1934) van den Berghe, 1937

Specific diagnosis.- Schistosoma: Conforming in all respects to the description of S. haematobium but with eggs larger and of a lozenge shape resembling those of S. bovis var. mattheei. Location purely intestinal. Parasites of man apparently limited to the region of Stanleyville, on the banks of the Congo in Africa.

SCHISTOSOMA JAPONICUM Katsurada, 1904

Synonyms.- Schistosoma Cattoi R. Blanchard, 1905; Bilharzia japonica (Katsurada, 1904) Hutyra and Marek.

Specific diagnosis.- Schistosoma:

Male 9.5 to 17.8 mm. long by 556 u to 967 u wide. Cuticle smooth except for small spines along gynaecophoric canal and in suckers. Oral sucker subterminal, 200 u to 350 u in diameter; acetabulum pedunculated, 156 u to 420 u in diameter, situated 550 u to 780 u caudad of oral sucker. The digestive tract is similar to that of S. haematobrium; intestinal ceca unite caudally about one-fourth of body length from posterior extremity of body. Testes 7 in number (6 to 8 according to some authors), situated near anterior end of gynaecophoric canal. Seminal vesicle spherical, 125 u in diameter, and situated immediately in front of the first testis.

Female 15 to 20 mm. long and 312 u to 358 u wide at the cecal union. Cuticle smooth. Oral sucker subterminal, 60 u in diameter, situated 266 u to 298 u caudad of oral sucker. Ovary elongate, 580 u to 700 u long by 135 u to 185 u wide, situated at equator, or caudad of equator of body. Uterus long and containing numerous eggs. Genital pore immediately caudad of acetabulum. Vitellaria occupy the space from the cecal union to the posterior end of the body, and are composed of transversely elongated follicles lying on both sides of the common cecum. Egg oval, 74 u to 106 u long by 60 u to 80 u wide, provided with a small, lateral, hooked or rudimentary spine.

Cercaria furcocercous, apharyngeal, spinose. Body 100 u to 160 u long by 40 u to 66 u wide; tail stem 140 u to 160 u long by 20 u to 35 u wide; furcal rami 50 u to

75 u long. Oral sucker 54 u long by 33 u wide; acetabulum small. Penetration glands consist of five pairs of large nucleated cells with grandular, acidophilic cytoplasm; penetration gland ducts very thick, opening at the anterior end of oral sucker and capped by five pairs of hollow piercing spines. The germ cells consist of a clustered mass immediately caudad of the acetabulum. The excretory system pattery consists of three pairs of flame cells in the body and one pair in the tail stem.

Hosts.- Primary, man, Bos sinicus,[3] cattle (Bos taurus), dog, cat, horse, swine, sheep, and experimentally, guinea pigs, monkeys, rabbits, rats, and mice; secondary, snails (katayama nosophora and K. n. yoshidai in Japan; K. formosana in Formosa; Oncomelania (Hemibia) hupensis, Katayama fausti, and K. f. cantoni in China.)

Location.- Portal and mesenteric veins.

Distribution.- Asia (China, Japan, Formosa, India, and Philippine Islands), and Africa.

SCHISTOSOMA MANSONI Sambon, 1907

Synonyms.- Distoma haematobium Bilharz, 1852, pro porte, Bilharz, Looss, et al.; Schistosomum Americanum da Silva, 1909; Bilharzia Manson (Samson, 1907) Ascanio-Rodriguez, 1916; Distomum mansoni (Samson, 1907 Iturbe, 1917.

Specific Diagnosis.- Schistosoma:

Male about 10 mm. long by 1.2 mm. wide. Body form similar to that of S. haematobium. Cuticle tuberculate and spiny. Oral sucker subterminal; acetabulum pedunculated and situated about 530 u caudad of oral sucker. Esophagus surrounded by esophageal glands; intestinal ceca short, uniting in front of equator of body; common cecum very long terminating near the posterior extremity of the body. Testes small, 8 to 9 in number, situated at anterior end of gynaecophoric canal. Seminal vesicle small, in front of testes. Genital pore opens in median line about the level of the first testis.

Female 15 mm. long filiform, and about 170 u wide. Sucker small; acetabulum situated about 224 u to 252 u caudad of the oral sucker. Digestive system similar to that of male. Ovary elongate in anterior half of body and

[3] Brumpt (1922) gives Bos Sinicus as a host for S. japonicum. This host name is not recognized by mammalogists, and since no geographical locality is given, its identity is problematical.

immediately in front of cecal union. Uterus short and usually containing but one egg at a time. The vitellaria occupy about two-thirds of the body length, extending posteriorly from immediate caudad of cecal union. Egg oval 120 u to 160 u long by 60 u to 70 u wide, and provided with a strong lateral spine.

Cercaria furcocercous, apharyngeal, spinose. Body 140 u to 190 u long by 50 u to 75 u wide; tail stem 200 u to 260 u long by 35 u to 40 u wide; furcal rami 50 u to 75 u long. Oral sucker 30 u to 60 u wide; acetabulum small. Penetration glands consist of two pairs of large nucleated acidophilic granular cells and four pairs with small nuclei and basophilic cytoplasm; penetration gland ducts very thick, opening at the anterior end of the oral sucker and capped by six pairs of hollow piercing spines. Germ cells small and situated caudad of acetabulum. Excretory system pattern consists of three pairs of flame cells in the body and one pair in the tail stem.

Hosts.- Primary, man, and experimentally, rats and mice; secondary, snails (Planorbis boissyi in Egypt; Planorbis pfeifferi, Physopsis africana and Bulinus Tropicus in South Africa; Planorbis guadelupensis in Venezuela; Planorbis centimetralis and P. olivaceus in Brazil; and P. antiguensis and Australorbis glabratus in the West Indies.)

Location.- Mesenteric veins.

Distribution.- Africa, South America, and West Indies.

SCHISTOSOMA INDICUM Montgomery, 1906

Synonym.- Bilharzia indica (Montgomery, 1906) Hutyra and Marek, 1910.

Specific Diagnosis.- Schistosoma:

Male 8.35 to 17 mm. long; anterior part of body straight 1 to 1.5 mm. long, and 400 u wide, posterior part of body cylindrical due to inrolling of the edges to form the gynaecophoric canal; maximum dorsal width 350 u and greatest dorsoventral width 400 u to 500 u. Cuticle tuberculate and spiny. Oral sucker subterminal infundibuliform, 270 u to 320 u in diameter; acetabulum pedunculated 350 u to 425 u in diameter and situated 0.9 to 1.5 mm. caudad of oral sucker. Esophagus 425 u long; cecal branches unite caudally about 0.85 to 1.5 mm. from posterior end of body, forming a common cecum which terminates about 100 u from posterior extremity. Testes 5 to 9 in number, situated 400 u caudad of acetabulum; seminal

vesicle small, 85 u in diameter and lying in front of the first testis; the genital pore opens in the median line at the anterior end of the gynaecophoric canal. The excretory bladder is 80 u long; excretory pore terminal.

Female 9 to 22 mm. long and 190 u wide. Cuticle smooth except for a few spines on the posterior end of the body and on the inside of suckers. Oral sucker small, subterminal; acetabulum 50 u to 60 u in diameter, usually extracted. Esophagus 230 u long; cecal branches unite caudad of ovary, forming a slender common cecum which terminates about 200 u from the posterior extremity. Ovary situated at equator of body, oval in shape, 500 u by 750 u long by 100 u wide; uterus 5 to 7 mm. long; genital pore immediately caudad of acetabulum. Vitellaria lie on each side of the common cecum and extend from the cecal union to 200 u to 300 u from the posterior end of the body. Egg oval and provided with a spine at one pole; uterine egg from 92 u to 100 u long by 42 u to 44 u wide, spine 14 u long; mature egg in tissue from 120 u to 140 u long by 68 u to 72 u wide.

Cercaria unknown or unrecognized.

Hosts.- Primary mammals (Equus caballus, E. asinus, Camelus dromedarius, and Ovis aries); secondary, unknown.

Location.- Mesenteric, pancreatic, pelvic, portal, and hepatic veins.

Distribution.- India

SCHISTOSOMA BOVIS (Sonsino, 1876) R. Blanchard, 1895

Synonyms.- Bilharzia Bovis Sonsino, 1876; Bilharzia crassa Sonsino, 1878; Bilharzia ovis Cobbold, 1885; Gynaecophorus crassus (Sonsino, 1878) Stossich, 1892; Gynaecophorus bovis (Sonsino, 1876) Railliet, 1892; Bilharzia haematobia crassa (Sonsino 1878) Kowalewskii, 1895; Schistosoma crassum (Sonsino, 1876) Looss, 1899.

Specific Diagnosis.- Schistosoma:

Male 9 to 14 mm. long. Cuticle with tubercles and spines. Oral sucker subterminal, 230 u long and 150 u deep; acetabulum 420 u in diameter. Esophagus 500 u long; cecal branches unite posteriorly at the beginning of the posterior fourth of the body and may show two or three anastomoses before their final union; common cecum terminates near posterior end of body. Testes 3 to 6 in number (usually 4, according to Khalil (1924), each 120 u long by 100 u wide, in a row on dorsal aspect of body, caudad of acetabulum. Seminal vesicle pear-shaped, 80 u in diameter, and situated immediately ~~in~~ front of the anterior testis.

Cirrus pouch and prostate absent. Genital pore slightly salient and situated immediately caudad of the acetabulum.

Female 12 to 17 mm. long, cylindrical, and attenuated at the extremities. Cuticle smooth and without spines. Oral sucker small, 40 u in diameter; acetabulum usually retracted, 50 u in diameter. Intestinal ceca unite caudally at the posterior fourth of the body; common cecum relatively short and terminating about 160 u from posterior extremity. Ovary elongated, 300 u long and 150 u wide, and situated immediately in front of cecal union. Shell gland small and ill-defined, situated in front of anterior pole of ovary. Uterus long and containing numerous eggs. Vitellaria consist of elongate, densely packed follicles, beginning about 100 u caudad of ovary and extending about 800 u from posterior extremity. Egg spindle-shaped, symmetrical, 160 u to 180 u long, by 50 u to 60 u wide, and provided with a blunt spine at one pole.

Hosts.- Primary, mammals (Bos taurus, Ovis aries and man); secondary, snails (Physopsis africana in South Africa, the host of Cercaria octagena which is regarded by Faust (1926) as the larva of S. bovis; Bulinus truncatus.

Location.- Portal and intestinal veins.

Distribution.- Europe (Italy, Sardinia, and Sicily), Asia (India, Annam, and Malay States), and Africa (Eghpt, South Africa, Tunesia).

SCHISTOSOMA BOVIS var. MATTHEEI
(Veglia & Leroux, 1929) van den Berghe, 1937

Specific Diagnosis.- Schistosoma: Conforming in all respects to the description of S. bovis as modified by MacHattie and Chadwick (1932):

(a) Lenght, 12 to 28 mm.

(b) Measurements of the egg in utero, 90 to 205 u by 40 to 95 u. Measurements of the egg in the gut wall, 130 to 260 u by 40 to 95 u.

(c) Only rare specimens show the vitellaria confined to the posterior fourth of the female. In the vast majority of the females the vitellaria occupy little less than half the length of the body.

(d) The shape of the egg is usually that described by Khalil but approximately .1 per cent of females show somewhat oval-shaped eggs.

(e) About 1 per cent of females show many typically shaped Schistosoma bovis eggs in utero and in the same uterus one or more typically shaped

Schistosoma haematobium eggs having the same measurements as the egg of this parasite of humans.

(f) Approximately .2 per cent of females contain solely eggs of Schistosoma haematobium shape and measurement. Such females are only distinguishable from this parasite of man in that the vitellaria occupy approximately one-half of the body length.

The eggs are very polymorphous, most frequently lozenge-shaped. For equal widths of eggs, the body is twice as wide as that of S. bovis. The ovary has a regular cylindrical shape. Distributed in the Belgian Congo and Irak.

SCHISTOSOMA CURASSONI[4] Brumpt, 1931

Specific diagnosis.- Schistosoma:

Male 10 to 15 mm. long by 600 to 700 u in maximum width. Gynaecophoric canal well developed, right lip much larger covering left lip to some extend. Cuticle smooth from beginning of anterior extremity to start of gynaecophoric canal; covered with tubercles with small spines; verrucae diminish in size and number a short distance from the caudal extremity of the body. Oral sucker deep and subterminal furnished with small spines. Acetabulum partially invaginated, thick, wrinkled edges, and 250 u in diameter in retraction. Acetabular cavity covered with small spines. Esophagus short branching above acetabulum into two sinuous branches which untie in the last fifth of the body forming the common cecum which ends 20 u from the posterior end of the body. Four testes of equal size about 100 u in diameter, situated in the dorsal part of the body 150 u back of the posterior edge of the acetabulum. Seminal vesicle tubular, below and forward of testes; communicates with genital pore by a short ejaculatory canal 4 u long. Genital pore located in the middle of the ventral face at the beginning of the gynaecophoric canal.

Female filiform, 13 to 14 mm. long by 250 u in maximum

[4] Closely resembles Schistosoma bovis var. mattheei, but until the life cycles are definitely established and eggs are found which show greater similarities, the writer believes that Schistosoma curassoni is a valid species.

width. Cuticle striated, 45 u between striations, without verrucae and has spines only on the posterior end of the body. Small oral sucker subterminal with small spines. Acetabulum small. Esophagus short branching 150 u from anterior extremity of body into two sinuous branches uniting into a common cecum directly after ovary. Voluminous ovoid ovary a little forward of union of two ceca. Uterus long containing numerous eggs. Vitellaria large granular glands arranged transversely on either side of long cecum and ending at 105 u from the posterior end of the body. Excretory pore terminal. Eggs with a terminal pole; 110 to 120 u long by 30 to 40 u wide.

Hosts.- Primary, oxen; secondary, unknown.

Location.- Veins of the liver (eggs in intestinal walls).

Distribution.- Bamakou, French Sudan.

SCHISTOSOMA RODHAMI Brumpt, 1931

Specific diagnosis.- Schistosoma:

Male 6.5 mm. long by 400 u in maximum width. Gynaecophoric canal well developed with right lip more developed than left. Cuticle striated, striations 1.5 u apart, smooth in preacetabular portion of the body and covered with tubercles in postacetabular portion up to the posterior end of the body. Oral sucker subterminal, oblique, 50 u in diameter, and containing small spines. Acetabulum circular, sessile, 250 u in diameter, located 500 u from anterior extremity and covered with small spines. Esophagus short surrounded by small glands; branches at level of anterior edge of acetabulum into two branches which unite to form the common cecum forward of the posterior third of the body; common cecum ends 200 u from the caudal extremity. 6 to 8 testes located dorsally at the level of the beginning of the gynaecophoric canal. Seminal vesicle difficult to trace. Genital pore invisible.

Female filiform 9-10.5 mm. long by 200 u in maximum width. Cuticle with striations 2 u apart; no tubercles but short spines anterior of suckers and on the last 200 u of the body. Oral sucker subterminal, central, and oblique, 52 u in diameter. Circular sessile acetabulum 50 u in diameter 250 u from anterior end. Short esophagus bifurcating forward of the acetabulum; branches unite in common cecum which forms 11/18 of the total length of the intestine. Ovary fusiform filling two-thirds of width of body a little forward of where the common cecum is formed. Uterus long containing several eggs; extending posteriorly an oötype

which joins the shell gland where the sole vitelline duct and oviduct end. Vitelline composed of numerous follicles which extend on each side of the common cecum. Eggs symmetrical possessing a terminal pointed spine which curves in an opposite direction from the slightly elongated rounded opposite end. Measure 65-70 u by 30 to 33 u in the uterus and as ripe eggs 145 by 58 u. Miricidium 110 by 35 u.

Host.- Primary, normal unknown, experimental, mice; secondary, longo mollusc.

Location.- Liver and mesenteric veins. Eggs found in intestinal walls and liver.

Distribution.- Elizabethville, Belgian Congo.

SCHISTOSOMA SPINDALIS Montgomery, 1906

Synonym.- Bilharzia spindalis (Montgomery, 1906) Conner, 1912.

Specific Diagnosis.- Schistosoma;

Male 8.24 to 9.58 mm. long by 527 u thick (45 to 12.2 mm. long by 250 u to 667 u wide according to Bryburg (1907). Cuticle covered with tubercles and spines; spines are also present in suckers and at borders of gynaecophoric canal. Oral sucker 306 u in diameter; acetabulum pedunculated, 357 u in diameter, and situated 900 u caudad of oral sucker. (Oral sucker 300 u by 250 u; acetabulum 267 u in diameter and 767 u caudad of oral sucker, according to Bryburg.) Testes 6 to 7 in number, each 85 u in diameter. Caudal end of body terminates in a conical projection and at the apex is located the excretory pore.

Female 14.1 mm. long by 200 u wide. (7.17 to 7.25 mm. long by 150 u to 175 u wide, according to Vryburg). Cuticle devoid of spines except at the posterior end of body and in cavity of oral sucker. Oral sucker subterminal, 68 u in diameter; acetabulum small, retracted, and situated 268 u caudad of the oral sucker. Esophagus simple; intestinal ceca unite posteriorly 7.702 mm. caudad of esophageal bifurcation; common cecum 6 mm. long and terminating 144 u from posterior end of body. Ovary oval and situated posterior of equator of body. Vitellaria are composed of discrete follicles lying lateral to the common cecum and extending posteriorly from the cecal union to within a short distance of the posterior extremity of the body. Egg spindle-shaped, symmetrical, with a spine 14 u to 15 u long present at one pole; uterine egg 284 u by 44 u wide; immature egg, in which embryo is not defined, 304 u to 316 u long and 52 u to 54 u wide; mature egg containing miracidium,

364 u to 400 u long by 68 u to 72 u wide at the widest portion and 12 u to 14 u across the polar prolongations.

Cercaria furcocercous, apharyngeal, spinose. Total length 490 u; body 200 u long by 50 u wide; tail stem 290 u long by 30 u wide; furcal rami 100 u long. Oral sucker 60 u long by 40 u wide; acetabulum 20 u in diameter. Penetration glands consist of five pairs of pyriform cells, the two anterior pairs being acidophilic, coarsely granular, and with large nuclei and the posterior three pairs being finely granular, basophilic, and with somewhat large nuclei. Penetration gland ducts thick, opening at anterior end of oral sucker, and capped by five pairs of hollow piercing spines. The germ cells, 24 in number, lie caudad of acetabulum. The excretory system pattern consists of four pairs of flame cells in the body and one pair in the tail stem.

Hosts.- Primary, mammals (Bos (Bubalus) bubalis Linnaeus, 1776), and man;[5] and experimentally, goat, water buffalo, monkey (Maceca sinica), guinea pig, and rats; secondary, snails (Planorbis exuatus and rarely Lymnaea acuminata in India; Planorbis pfeifferi and Bulinus tropicus in Africa).

Location.- Mesenteric and portal veins.

Distribution.- Asia (India and Sumatra) and Africa (South Africa).

[5] In 1926 Porter described a new variety of S. spindalis from South Africa for which she proposed the name S. spindalis variety Africana. The characters upon which the new variety is based are the egg size, smaller than that described by Montgomery for the Indian species, and also a cercaria smaller than that described by Soparker (1931). The eggs of the new variety were obtained from the urine of man and measured 163 u to 258 u long by 46.4 u to 70 u wide. The cercaria obtained by infecting Planorbis pfefferi and Bulinus tropicus, measured as follows: Body 153.3 u to 183 u long by 21 u to 26.6 u wide; oral sucker 40 u to 53.3 u long by 30 u to 33 u wide; acetabulum 18.5 u by 26.6 u.

The reported occurrence of S. spindalis in man includes at least three apparently authentic cases, one reported by Lawston (1925) and two by Porter (1926), and there are one or two doubtful cases. Danbury (1923) considers the egg reported from the urine of a Madras native by Christophers and Stephens (1905) as probably belonging to this species. It is possible that the eggs described from human urine by Chesteradad (1923) may also be those of S. spindalis.

SCHISTOSOMA SUIS Rao, 1933

Synonym.- Schistosoma incognitum Chandler, 1926.[6]

Specific Diagnosis.- Schistosoma:

Male 4 to 6 mm. in length. Constriction a little behind the ventral sucker which can be said to divide it into a short anterior portion more or less subcylindrical and a longer posterior portion whose lateral margins curve ventrally to form the gynaecophoral canal. The anterior portion which is spindle-shaped carries the oral and ventral sucker. The cuticle lining the suckers, and that lining the gynaecophoral canal is spiny. The cuticle of the anterior portion of the parasite is smooth, but that covering the dorsal surface of the posterior part is covered with moderately large tubercles, majority of which bear a few spines on them. The posterior extremity of the male is truncated. The oral sucker is subterminal or it appears to be so, owing to the overhanging dorsal rim. The diameter is about 0.15 mm. The wall of the oral sucker is thick and encloses a funnel-shaped cavity leading into a thin-walled esophagus. The ventral sucker is somewhat larger than the other and measures 0.18 mm. in diameter. It is pedunculated. The alimentary canal begins with the esophagus which is short and it bifurcates in front of the ventral sucker dorsally only to unite in the region about the beginning of the middle third of the

[6] Chandler (1926) has described Schistosoma ova from samples of what he believed to be human feces which were collected from defecation areas near two villages to which pigs had access. These ova resemble in all respects those of S. suis. Chandler assumed that such feces, from which he obtained samples, were passed by human beings because of the stools and the presence of ova of Anclyostomas, Ascaris, and Trichuris, but, for obvious reasons that cannot be taken as evidence to prove the correctness of his assumption. The fact that the Schistosoma ova described by him resemble those found in the schistosomes collected from pigs, suggests the possibility that the feces in which he saw them were from the pigs that had access to the areas mentioned by him, and not from human beings. Furthermore, the various schistosomes described from mammals can be differentiated by the shape of their ova, and since the shape of the ova of the parasites in question is different from the others, there appears to be justification in making it a new species and Rao has proposed to name it "S. Suis." Now that the adult schistosome and its host has been found, Rao suggests placing

to form a blindly ending common cecum which terminates 0.2 mm., from the truncated posterior extremity of the worm. The anterior third of the common cecum appeared to possess small diverticulae in one worm. The visible excretory system consists of a small elongated bladder 0.08 mm., in length and opens on the posterior margin of the worm. The bladder has two cornua anteriorly, each of which disappears in the tissue on either side of the parasite. The genital glands consist of 4 to 7 testes which lie apparently in a row in the median line, in the dorsal aspect, behind the ventral sucker and each gland is almost rectangular when viewed ventrally. The visicular seminis is placed in front of the testis and opens ventrally just behind the ventral sucker.

Female cylindrical, has nearly uniform thickness excepting at the ends which taper slightly. The cuticle is smooth. The length varies from 4.9 to 6 mm. The oral sucker is subterminal and much more developed than the ventral sucker. It is about 0.05 mm. in diameter and leads into the esophagus. The ventral sucker projects from the body and appears to be much more developed than the corresponding sucker in other species of female schistosomes found in mammals. Its diameter is about 0.03 mm. The alimentary canal, as in the male, begins with the esophagus, bifurcates in front of the ventral sucker and the two ceca thus formed reunite at the end of the anterior fourth of the body just behind the ovary. The ovary is a solid granular organ, more or less pyriform, the broader end of which is directed anteriorly. It measures about 0.2 by 0.06 mm. The oviduct begins at the posterior pole, and immediately bends forward, passes by the side of the ovary and in front of the ovary it meets an ill-defined granular body, the shell gland. The vitellaria begin 0.19 mm. from the posterior extremity of the ovary and are in the form of loosely packed granular clumps around the whole length of the common cecum. The vitellaria ducts meet the oviduct a little behind its origin. The uterus which is a fairly wide tube passes forward in a zigzag manner between the intestinal ceca and opens just behind the ventral sucker apparently on a small apapilla. Only one ovum could be seen in the uterus of each of the specimens available.

The egg is yellowish brown in color, suboval in shape with one side flattened. There is a small stout spine which is subterminal and inclines towards the flattened

S. in cognitum Chandler, 1926, as a synonym of S. Suis because even though the former name is older it is only a nomen nudula, with which suggestion the writer is in agreement.

side. The egg *in utero* measures 0.09 by 0.041 mm. and the spine measures about 7.5 mm. in length. The egg shell is thin.

Hosts.- Primary, pigs; secondary, unknown.
Location.- Mesenteric veins.
Distribution.- India (Madras).

SCHISTOSOMA NASALIS Rao, 1933

Specific Diagnosis.- Schistosominae:

Male, length 6.3 to 11 mm. Cuticle coarsely tuberculate. Occasional branching and uniting of common cecum as in *S. bovis*. 2 to 4 testicular glands irregularly elliptical.

Female, length 5 to 11 mm. Common cecum 4.19 to 6.93 mm. long. Ovary, post-equatorial; uterus containing 1 to 5 ova. Length of common cecum one-third of parasite.

Ova, elongate spindle; length 336 to 580 u and breadth 60 to 80 u. Middle one-third of body of ovum, which is concavo-convex, is prolonged into a horn on either side, one bluntly rounded, the other prolonged into a spine. Spine curved toward concave border. Base of ovum concave.

Miracidia almond shaped; protrusible, semi-circular snout on anterior end. 10 to 12 ciliary groups on girdle. Cilia covers all of body except around two papillae on shoulders. Small oral opening in snout leads to short tubular or saccular gut which extends backward to a rounded group of small secretory glands. Glands longer than gut. Excretory system, consists of anterior and posterior flame cell in each mesial half of body.

Cercaria small, apharyngeal, and brevifurcate. Body covered with small thin spines pointing backward. Tail, stem and furcal rami covered over with coarser spines. Pear-shaped body at posterior end. Muscular, oval penetrating organ at anterior end crowned with ten hollow spines. Ventral sucker at beginning one-fourth of posterior part of body. Lined with three or four rows of fine spines. Oral opening subterminally penetrating organ leads to fine tubular esophagus ending in dilated sac in front of ventral sucker. Five pairs of secretory glands, with ducts leading to hollow spines. Excretory system consists of bladder at posterior end of body with three pairs of flame cells in body and one pair in tail stem. Caudal excretory canal down tail stem bifurcating into rami leading to funnel-shaped excretory pore at end of each rami.

Hosts.- Primary, cattle and buffalos; secondary, snails (Limnea accuminata, L. lauteola, Planorbis exustus).

Location.- Veins in trubinate folds of mucous membrane of nose.

Distribution.- India

SCHISTOSOMA MARGREBOWIEI Leroux, 1933

Synonym.- Bilharzia margrebowiei Leroux, 1933.

Specific diagnosis.- Schistosoma:

Male 12 to 18 mm. long by .857 mm. to 1.254 mm. wide. Cuticle armed with bosses and spines dorsally and spines ventrally. Inner surface of suckers provided with spines. Oral sucker subterminal, with a lateral diameter of 200 u to 240 u. Ventral sucker pedunculated and situated at a variable distance, according to the state of contraction of the individual, from the oral sucker. Usually four testes, rarely five, measure approximately 176 u by 160 u. The seminal vesicle lies in front of the testes and is variable in dimensions depending on the sexual activity of the individual at the time of collection. In some specimens the measurements of this organ were 176 u by 112 u. The intestinal ceca unite very late.

Female 14 mm. to 20 mm. long by 270 u to 320 u wide. Inner surfaces of both suckers and posterior portion of body armed with spines. Ovary, somewhat pear-shaped, 688 u long by 225 u wide and situated at equator of body. Uterus long and containing numerous eggs arranged in clumps. Eggs practically oval 60 u by 40 u to 70 u by 42 u, provided with a small subterminal knoc, rudimentary or well-developed spine. Vitellaria occupy the posterior half of the worm.

Cercaria unknown or unrecognized.

Hosts.- Primary, ruminants (cattle, zebra, lechwe kobs (Cobus leche Gray), reedbuck (Redunca arundinum Bodd.), pukus (Cobus vardoni taurinus Burch.), a situtunga or water kudu (Tragelaphus spekei selousi Roth), and a roan antelope (Hippotragus equinus Desm.); secondary, unknown.

Location.- Radicles of the portal vein.

Distribution.- Africa (North Rhodesia).

SCHISTOSOMA FARADJEI Walkiers, 1928

Eggs found in feces of man in Africa, presumably Belgian Congo. No characters are given except that the

egg is unarmed-spineless.[7]

Genus SCHISTOSOMATIUM Tanabe, 1932

Generic Diagnosis.- Schistosominae: Male large and longer than female. Suckers present, well developed. Anterior two-fifths of body flattened; posterior three-fifths infolded to form the gynaecophoric canal. Intestinal ceca provided with lateral diverticu and united near posterior end of body. Testes 14 to 18 in number, arranged in two rows at anterior end of gynaecophoric canal. Genital pore median, in front of anterior testis. Female flattened. Ovary in anterior half of body. Uterus containing numerous oval, spineless eggs. Genital pore caudad of acetabulum. Vitellaria composed of lobulated, densely packed follicles extending from the distal pole of ovary to posterior end of body.

Larva a furcocercous, apharyngeal cercaria, with eye-spots, and with an excretory system consisting of six pairs of flame cells, one pair of which is located in the base of the tail stem.

SCHISTOSOMATIUM PATHLOCOPTICUM Tanabe, 1932

Synonym.- Schistosoma pathlocopticum Tanabe, 1923.

Specific Diagnosis.- Schistosomatium:

Male 5.6 to 11.8 mm. long by 400 u to 900 u wide. Anterior portion of body flattended, 2.4 to 4.7 mm. long by 260 u to 580 u wide; posterior portion, 3.2 to 7.1 mm. long by 1.04 mm. wide when flattened, with edges infolded forming a gynaecophoric canal; between the anterior and posterior portions the body is narrowed and is 240 u to 410 u wide. Cuticle spiny, but without tubercles. Oral sucker subterminal, 130 u to 160 u in diameter; acetabulum pedunculated, 250 u to 260 u in diameter. Esophagus simple, about 520 u long; intestinal ceca provided with short lateral diverticula and united posteriorly about 600 u from the caudal extremity; common cecum short and terminating about 140 u from posterior end of body. Testes 14 to 18 in number, spherical, 100 u to 180 u in diameter, in two parallel rows in the median line and slightly pre-equatorial. Seminal vesicle large, semilunar

7 May be identical with S. margrebowei Leroux, as this species possesses unarmed eggs, although S. margrebowei is not known to be parasitic in man.

in outline, and situated to the left of the median line. Excretory system consists of two slender, lateral tubes which unite to form a common tube opening slightly dorsad at the extreme posterior end of the body.

Female 4.5 to 10.2 mm. long by 180 u to 380 u wide. Suckers weak and rudimentary. Cuticle spiny in anterior part of body, especially around suckers and genital pore. Ovary oval in shape and situated in front of equator of body. Shell gland poorly defined, in front of ovary, and at junction of oviduct, vitelline duct, and uterus. Uterus about 500 u long, and filled with eggs. Vitellaria, composed of densely packed lobulated follicles, and occupying almost the entire space from the ovary to the posterior end of the body. Egg oval, 59 u long by 40 u wide, without spine.

Cercaria furcocercous, apharyngeal, spinose. Total length 410 u; body 180 u long by 80 u wide; tail stem 230 u long by 45 u wide; furcal rami 100 u long. Eyespots present, pigmented, .8 u in diameter, lying near equator of body. Oral sucker 50 u long by 47 u wide; acetabulum 24 u in diameter. Penetration glands consist of three pairs of acidophilic cells which nearly fill the postacetabular region of the body; penetration gland ducts open at anterior end of acetabulum and are capped by an equal number of hollow piercing spines. The germ cells lie in the median line caudad of the acetabulum. Excretory system pattern consists of five pairs of flame cells in the body and one pair in the tail stem.

Hosts.- Primary, mammals (white rats and mice, experimentally); secondary, snail (Lymnae palustris).

Location.- Intestinal veins, portal vein and liver.

Distribution.- North America (U.S.A. (Boston, Mass.)).

SCHISTOSOMATIUM DOUTHITTI (Cort, 1915) F. Price, 1931

Synonym.- Cercaria douthitti Cort, 1915.

Specific diagnosis.- Schistosomatium:

Male length, 1.900 to 6.339 mm. Cirrus and cirrus pouch present; testes 15 to 36; genital pore ventral and on left side at anterior end of gynaecophoric canal; transverse commissures joining intestinal ceca in front of cecum.

Female length, 1.138 to 5.356 mm.; oötype and seminal receptacle present; transverse commissures joining intestinal ceca in front of cecum.

Cercaria, six pairs of penetration glands, first pair present only before normal emergence of larva from

snail host; unicellular, subcuticular glands.

Miracidium possesses twenty-one ciliated epidermal cells arranged in transverse tiers; two rows of sensory cells, a posterior row terminating in bristle patches in non-ciliated area between first and second tier of epidermal plates, an anterior row terminating at base of anterior papilla without bristle patches; one pair lateral nerves.

Hosts.- Primary: natural, Microtus pennsylvanicus; experimental, mice belonging to the genera Peromyscus, Mus, and Microtus; rats belonging to the genera Rattus. Secondary, snails (Lymnaea stagnalis appressa Say, Lymnaea stagnalis perampla Walker, Lymnaea reflexa Say, Lymnaea palustris Muller, Physa ancillaria parkeri Cuvier, Physa gyrina elliptica Lea, Onadatra Zibethica).

Location.- Hepatic portal system.

Distribution.- U.S.A. (Chicago, Ill., Douglas Lake, Mich., Ann Arbor, Mich., Minneapolis, Minn.)

Genus PARASCHISTOSOMATIUM Price, 1929

Generic Diagnosis.- Schistosominae: Male unknown. Female slender, flattened, and tapering toward extremities. Cuticle smooth. Oral sucker subterminal, well developed; acetabulum pedunculated. Esophagus simple; intestinal ceca without lateral diverticula and united caudally near posterior end of body; common cecum very short. Ovary spirally curved, in posterior third of body; uterus long and filled with eggs. Vitelline follicles few in number, situated posterior to ovary and between cecal branches.

PARASCHISTOSOMATIUM ANHINGAE Price, 1929[8]

Specific Diagnosis.- Paraschistosomatium: Male unknown. Female 6.9 mm. long by 325 u wide. Body flattened and tapering gradually toward extremities. Cuticle smooth and without spines except in suckers. Suckers equal in size, 143 u in diameter; oral sucker subterminal; acetabulum pedunculated and situated 480 u caudad of oral sucker. Esophagus simple, bifurcating in front of acetabulum; intestinal ceca unite caudally about 460 u from posterior end of body; common cecum 200 u long.

[8] This trematode is probably more closely related to species of the genus Schistosomatium than those of any of the other genera. The union of the intestinal ceca

Ovary spiral, 585 u long as measured in a straight line and exclusive of length of spiral, and situated on the anterior part of the posterior third of the body. Vitellaria consists of a few scattered follicles lying posterior to the ovary and between cecal branches. Genital pore is situated immediately caudad of acetabulum. Uterus long and filled with thin-shelled eggs, which measure about 70 u long by 43 u wide.

Cecaria unknown or unrecognized.

Hosts.- Primary, birds (Anhinga anhinga); secondary, unknown.

Location.- Portal vein.

Distribution.- North America (U.S. (Texas))

Genus HETEROBILHARZIA Price, 1929

Generic Diagnosis.- Schistosominae: Preacetabular portion of male short, subcylindrical; posterior portion with edges inrolled, forming a deep gynaecophoric canal. Suckers present. Cuticle covered with small tubercles. Intestinal ceca unite caudally near posterior end of body. Testes numerous, 70-83 in number, arranged in two irregular rows in posterior third of body anterior to cecal union. Cirrus pouch present and containing seminal vessels. Genital pore situated at beginning of the gynaecophoric canal and to the left of the median line. Female unknown.

HETEROBILHARZIA AMERICANA Price, 1929

Specific Diagnosis.- Heterobilharzia: Male 10 to 14 mm. long by 3 mm. wide. Cuticle covered with small tubercles. Oral sucker subterminal, 350 u to 355 u in diameter; acetabulum pedunculated, 426 u to 453 u in diameter, situated about 568 u caudad of oral sucker. Esophagus long and surrounded by the esophageal glands; intestinal ceca sinuous and uniting about 500 u to 750 u from posterior end of body; common cecum short and terminating 140 u to 150 u from posterior end of body. Testes

near the posterior end of the body is similar to that in S. pathlocopticum in P. anhingae, however, the ceca do not have lateral diverticula, the ovary is more posterior, and the distribution of the vitelline follicles is very different from that of S. pathlocopticum. In view of these differences, E.W. Price (1929) has tentatively proposed the new genus Paraschistosomatium to include this species.

70 to 83 in number arranged in two irregular rows between intestinal ceca in posterior third of body. Cirrus pouch elongated transversely, 210 u to 315 u long by 70 u wide, and situated about 568 u caudad of acetabulum; seminal vesicle oval and lying entirely within cirrus pouch. Genital pore 520 u caudad of acetabulum, and to the left of median line. Excretory system consists of a short bladder which opens at excretory pore at top of the body, and of two slender branches extending cephalad on each side of body.

Female unknown.

Cercaria unknown or unrecognized.

Hosts.- Primary, mammals (Lynx species, probably, L. ynita); secondary, unknown.

Location.- Mesenteric veins.

Distribution.- North America (U.S.A. (Wash. D.C. National Zoological Park)).

Genus AUSTROBILHARZIA, Johnston, 1917

Generic Diagnosis.- Schistosominae: Male shorter than female. Gynaecophoric canal extends from posterior edge of acetabulum to posterior end of body. Suckers well developed and prominent. Esophagus bifurcates in front of acetabulum; intestinal ceca unite caudally in the posterior fourth of body and may show several anastomoses before the final union; common cecum short. Testes 18 to 26 in number, situated between the ceca, originating anteriorly a short distance caudad of acetabulum, a little to the left of median line. Cirrus pouch present, enclosing the seminal vesicle and prostate. Female slender, the anterior portion threadlike and the posterior portion flattened. Oral sucker not developed, acetabulum present. Ovary long and loosely spiral. Vitellaria well-developed and occupying region behind ovary.

AUSTROBILHARZIA TERRIGALENSIS Johnston 1917

Specific diagnosis.- Austrobilharzia: Male 3.4 to 4 mm. long by 400 u dorsoventrally. Cuticle smooth. Suckers about equal in size, 175 u in diameter; acetabulum pedunculated and lined with fine spines. Intestinal ceca provided with small diverticula; in the posterior third of the body the ceca are united by commissures forming two loops which are separated by a short

stem; common cecum short and terminating near posterior end of body. Testes 18 to 20 in number, symmetrically placed between the intestinal ceca, originating about 200 u caudad of genital pore and extending to equator of body. Cirrus pouch moderately developed and enclosing the seminal vesicle and prostate. Genital pore situated about 125 u caudad of the acetabulumand to the left of the median line. The excretory system consists of a Y-shaped vesicle opening at the extreme posterior end of the body, with two fine ciliated tubes given off from the anterior limbs of the Y.

Female 4.5 to 5 mm. long; anterior part of body slender, 2.65 mm. long by 58 u in diameter; posterior portion flattened, 1.85 mm. long by 136 u wide. Oral sucker absent; acetabulum pedunculated, 35 u in diameter. Oral opening ventral, 30 u from the anterior end of body; esophagus 200 u long; intestinal ceca unite caudally at the union of the anterior and posterior parts of body; common cecum slender and terminating near posterior end of body. Ovary spirally curved, 388 u long when measured in a straight line, disregarding spiral length, and situated at the union of the anterior and posterior parts of the body. The oviduct extends forward and widens near its anterior end to form the uterus which contains a single egg. The genital pore is situated immediately behind and to one side of the acetubulum. The vitellaria occupy the space from the distal pole of the ovary to the posterior end of the body.

Egg 32 u long by 26 u wide.

Cercaria unknown or unrecognized.

Hosts.- Primary, birds (Hydrocoloeus novae-hollandiae=Larus novae-hollandiae); secondary, unknown.

Location.- Intestinal blood vessels.

Distribution.- Australia (New South Wales).

AUSTROBILHARZIA BAYENSIS Tubangui, 1933[9]

Specific Diagnosis: Austrobilharzia. Body of male elongate, 5.2 mm. in length by 0.32 mm. in maximum width across middle. Cuticle smooth. Oral sucker 0.18 by 0.14 mm. in size, anteroterminal. Acetabulum 0.22 mm. in anteroposterior diameter between first and second seventh of body length. Esophagus 0.7 mm. long, bifurcates immediately behind acetabular level. Ceca take a wavy posterior course

[9] Represented by a single male specimen collected from the migratory snipe, Gallinago gallinago. Differs only from Austrobilharzia terrigalensis in the number of its testis, which is twenty-six, the Australian form possessing only 18-20.

uniting about 1.5 mm. from posterior end of body; the resulting trunk reaches near posterior extremity. Gynaecophoric canal well developed, extends from immediately behind acetabulum to posterior end of body. Testes 26 in number, spherical or slightly compressed, longitudinal series from a short distance behind genital pore to middle of body length; the testicular expanse is about 0.5 mm. Cirrus pouch flask-shaped, 0.16 by 0.10 mm. in size; incloses seminal vesicle and prostate. Genital pore on ventral surface, about equidistant between acetabulum and first testis.

Female unknown.

Hosts.- Primary, birds (Gallinago gallinago); secondary, unknown.

Location.- Mesenteric veins.

Distribution.- Philippine Islands (Bay, Laguna, Luzon

Genus ORNITHOBILHARZIA Odhner 1912

Synonym.- Macrobilharzia Travassos, 1932.

Generic diagnosis.- Schistosominae: Female shorter than male. Male with well-developed gynaecophoric canal, formed by an infolding of the lateral edges of the body. Suckers present. Cuticle covered with spines. Digestive tract similar to that of Schistosoma; intestinal ceca long and showing a tendancy to form several anastomases before finally uniting to form the common cecum. Testes numerous (60 or more), commencing a short distance caudad of acetabulum, and extending into posterior half of body. Cirrus pouch rudimentary or absent. Seminal vesicle free in the parenchyma; prostate absent. Genital pore small and situated immediately caudad of acetabulum. Female elongate, slender and flattened. Ovary elongated, loosely or tightly coiled, and situated in anterior third of body. Vitellaria extensive, occupying about two-thirds of body length. Laurer's canal present (at least in some species). Uterus short and containing but one egg at a time.

ORNITHOBILHARZIA INTERMEDIA Odhner 1912

Specific diagnosis.- Ornithobilharzia:

Male 8 to 10.6 mm. long and 450 u wide. Cuticle provided with thick blunt spines. Oral sucker 200 to 250 u in diameter; acetabulum 300 to 350 u in diameter.

Testes 90 to 110 in number, commencing a short distance caudad of acetabulum and extending almost to posterior fourth of body; terminal portion of genital system (Endapparat) small and situated at posterior edge of acetabulum; seminal vesicle entirely outside of a rudimentary cirrus pouch; prostate absent. The genital pore is situated immediately caudad of the acetabulum and to the left of the median line.

Female 4.5 to 5.75 mm. long and 170 to 220 u wide in region of ovary. Cuticle spiny. Oral sucker 40 u to 50 u in diameter; acetabulum 25 u to 35 u in diameter. Ovary long, spirally twisted and situated in the anterior fourth of body. Vitellaria extend from a short distance caudad of ovary to posterior end of body. Egg 70 u long by 50 u wide.

Cercaria unknown or unrecognized.

Hosts.- Primary, birds (Larus fuscus and Hydrocoloeus melanocephalus); secondary, unknown.

Location.- Intestinal veins.

Distribution.- Europe (Sweden).

ORNITHOBILHARZIA CANALICULATA (Rudolphi, 1819 Odhner, 1912

Synonyms.- Distoma Canaliculatum Rudolphi, 1819; Bilharzia Canaliculata (Rudolphi, 1819) Braun, 1902.

Specific diagnosis.- Ornithobilharzia:

Male 16 mm. long and from 1 to 1.4 mm. wide. Oral sucker subterminal, 312 u long by 104 u to 106 u wide; acetabulum pedunculated, 450 u in diameter and 100 u to 150 u in height, and situated about 1 mm. caudad of oral sucker. Testes numerous, originating caudad of copulatory apparatus and extending posteriorly to equator of body. The genital pore is situated in anterior part of gynaecophoric canal. The cirrus pouch (?) lies at a right angle to the long axis of the body.

Female shorter than male, cylindrical, and thinner anteriorly than posteriorly, the anterior part of body being about 60 u wide and the posterior part about 145 u wide.

Cercaria: Unknown or unrecognized.

Hosts.- Primary, birds (Thalasseus maximus = Sterna galericulata); secondary, unknown.

Location.- Intestine, probably from intestinal veins.

Distribution.- South America (Brazil).

ORNITHOBILHARZIA KOWALEWSKII (Parona & Ariola, 1896) Odhner, 1912

Synonyms.- Bilharzia Kowalewskii Parona and Ariola, 1896; Schistosoma Kowalewskii (Parona and Ariola, 1896) Railliet, 1899; Bilharziella Kowalewskii (Parona and Ariola, 1896) Looss, 1899.

Specific diagnosis.- Ornithobilharzia:

Male 14 mm. long by 1 mm. wide. Oral sucker cup-like, subterminal, smaller than acetabulum, and measuring 364 u in diameter; acetabulum pedunculated, circular, 560 u in diameter. Cuticle without tubercles or spines. Esophagus bifurcates about 750 u caudad of oral sucker, common cecum short. The gynaecophoric canal originates abruptly just posterior to acetabulum and extends to posterior tip of body. Testes numerous, disposed in two rows commencing about 490 u caudad of acetabulum and terminating about one-fourth of body length from posterior end.

Female unknown.

Cercaria unknown or unrecognized.

Hosts.- Primary, birds (Hydrocoloeus melanocephalus); secondary, unknown.

Location.- Heart.

Distribution.- Europe (Italy).

ORNITHOBILHARZIA ODHNERI Faust, 1924

Specific diagnosis.- Ornithobilharzia:

Male 6 to 7 mm. long by 220 u to 260 u in cross section. Cuticle covered with spines. Oral sucker 120 u to 155 u in diameter; acetabulum 160 u to 165 u in diameter. The gynaecophoric canal is deep and broad. The esophagus branches immediately cephalad of the acetabulum; intestinal ceca sinuous, uniting caudally six-sevenths of body length from anterior end; common cecum short. Testes oval, about 65 in number, and lying in median line in equatorail three-sevenths of body. Seminal vesicle situated midway between anterior testis and acetabulum, and communicating directly with a rudimentary cirrus pouch, which lies dorsad of the genital pore; ejaculatory duct rudimentary; prostate absent.

10 So far as may be determined from Parona and Ariola's (1896) description, there appears to be no essential difference, as Odhner (1912) points out, between Ornithobilharzia kowalewskii and O. canaliculata. The available descriptions are, however, so incomplete that a study of specimens of these species is necessary before final decision should be made.

Female 3 mm. long by 100 u to 120 u in diameter in cross section. Cuticle covered with fine spines. Oral sucker equal to acetabulum in size and measuring 70 u in diameter. The esophagus bifurcates cephalad of acetabulum, and the intestinal ceca unite about four-fifths of body length from anterior end; common cecum short. Ovary elongate, loosely coiled, and situated in anterior third of body. The oviduct arises from the posterior pole of ovary, bending laterad and continuing anteriad to the oötype; seminal receptacle well developed, situated behind the ovary, and connected with oviduct by a short duct. Laurer's canal arises from dorsal aspect of seminal receptacle and opens through a minute pore on dorsal side of body. The vitellaria consist of paired follicles extending from a short distance caudad of seminal receptacle to near posterior end of body. The vitelline duct extends forward parallel with the oviduct and joins it at the oötype. Uterus short and containing a single egg. The genital pore occupies a median position immediately caudad of acetabulum.

Cercaria unknown or unrecognized.

Hosts.- Primary, birds (Asiatic curlew (Numenius arquatus)); secondary, unknown.

Location.- Portal vein.

Distribution.- Asia (China).

ORNITHOBILHARZIA MACROBILHARZIA (Travassos, 1923) Price, 1929

Synonym.- Macrobilharzia macrobilharzia Travassos, 1923.

Specific diagnosis.- Ornithobilharzia:

Male 40 to 57 mm. long and 3.5 mm. wide when folded. Postacetabular portion of body folded longitudinally but not permanently; preacetabular portion 4 mm. long and separated from posterior portion by a constriction. Oral sucker terminal, 740 u in diameter; acetabulum salient; 1.3 mm. in diameter. Esophagus 1 mm. long; pharynx absent; intestinal ceca sinuous and uniting caudally near posterior end of body. Testes 230 to 250 in number disposed in two rows in anterior half of body, and having an average diameter of 170 u to 200 u. Seminal vesicle present, pretesticular.

Female unknown.

Cercaria unknown or unrecognized.

Hosts.- Primary, birds (Anhinga anhinga= Plotus-anhinga, Marila Affinis);

Distribution.- South America (Brazil), United States (Maryland).

ORNITHOBILHARZIA TURKESTANICUM (Skrjabin, 1913) Price, 1929

Synonyms.- Schistosoma turkestanicum Skrjabin, 1913; Schistosoma bomfordi Montgomery, 1908.

Specific diagnosis.- Ornithobilharzia:

Male 4.2 to 8 mm. long by 340 u to 476 u wide. Cuticle without tubercles. Oral sucker subterminal, 255 u long by 154 u wide; acetabulum 289 u by 278 u, and situated about 425 u caudad of the oral sucker. The esophagus shows two dilations and is surrounded by the esophageal glands; intestinal ceca unite caudally about 1.2 mm. from posterior end of body; in some specimens transverse commissures are present in posterior half of body which connect the two ceca. The testes, 70 to 80 in number, occupy a space about 3 mm. long in the median line. The genital pore lies immediately caucad of the acetabulum.

Female 3.4 to 5.5 mm. long by 102 u wide in the region of the ovary; body slender and almost circular in cross section. The suckers measure 72 u in diameter, and the acetabulumis situated about 170 u caudad of the oral sucker. Esophagus simple; intestinal ceca unite 1.632 mm. from posterior end of body. Ovary spiral, 255 u long, and situated anterior to cecal union. The vitellaria are composed of elongated follicles which occupy the space from the cecal union to the posterior end of the body.

Eggs oval, 72 u to 74 u long by 22 u to 26 u wide, and provided with a spine-like prolongation at each pole.

Cercaria unknown or unrecognized.

Hosts.- Primary, mammals (Bos taurus and Felis domestica; secondary, unknown.

Location.- Branches of the portal vein.

Distribution.- Asia (Russian Turkestan and North China) and Europe (France).

ORNITHOBILHARZIA BOMFORDI (Montgomery, 1906) Price, 1929

Synonyms.- Schistosoma bomfordi, Montgomery, 1906.[11]

Specific diagnosis.- Ornithobilharzia:

[11] Schistosoma bomfordi Montgomery and S. turkestanicum Skrjabin were transferred by Price (1929) to the genus Ornithobilharzia on the basis of morphological similarity to other species of the genus.

Male 7.089 mm. long; anterior portion of body 357 u wide; posterior portion 408 u wide in region of testes and 170 u in diameter at caudal extremity. The anterior portion of the body is flattened and the posterior portion inrolled forming the gynaecophoric canal. Oral sucker cup-shaped, 306 u in diameter; acetabulum pedunculated, 306 u in diameter, and situated 850 u caudad of oral sucker. Testes 61 in number, oval in shape, and measuring 100 u by 90 u, the total length of the chain of testes being 3.06 mm., or about three-sevenths of the total body length. The seminal vesicle is situated in front of the testes, about 200 u caudad of the union of the anterior and posterior portions of the body.

Female 7.31 mm. long by 172 u wide at the ovary. Cuticle devoid of spines, except in suckers and at posterior end of body. Oral sucker subterminal, 46 u in diameter; acetabulum slightly salient, 42 u in diameter. Esophagus simple, 204 u long; intestinal ceca unite posteriorly 1.819 mm. from esophageal bifurcation; common cecum 5.109 mm. long and terminating 178 u from posterior extremity. Ovary oval in outline, 300 u long, and situated in front of cecal union. Uterus 1.4 mm. long; genital pore slightly salient, and situated immediately caudad of acetabulum. The vitellaria lie on each side of the common cecum and extend from the cecal union to the posterior end of the body.

Egg oval and provided with a terminal; immature egg 100 u to 115 u long by 44 u to 48 u wide, spine 6 u to

The number and position of the testes in the male, and the shape and position of the ovary in the female are so similar to those in Ornithobilharzia intermedia Odhner, type of Ornithobilharzia, that they are obviously congeneric. The fact that both O. bomfordi and O. turkestanicum are known only at present from mammalian hosts does not appeal to Price as being a matter of sufficient importance to justify their retention in the genus Schistosoma. In view of the morphological relationship of O. turkestanicum and O. bomfordi to species occurring in birds, it may be assumed that these parasites, which are of rare occurrence in their mammalian hosts, may be only accidental and facultative parasites of these hosts, and it may be surmised that they are normal parasites in birds of some sort. This writer is in agreement with Price and is of the opinion that until it can be definitely demonstrated that S. bomfordi and S. turkestanicum are not accidental and facultative parasites of mammals that their placement in the genus Ornithobilharzia is valid.

10 u long; mature egg, containing a miricidium, 125 u to 136 u long by 53 u to 60 u wide, spine 6 u to 8 u long.

Cercaria unknown or unrecognized.

Hosts.- Primary, mammals (Bos (Bubalus) bubalus= Bos indicus); secondary, unknown.

Location.- Mesenteric veins.

Distribution.- Asia (India).

ORNITHOBILHARZIA ORNITHOBILHARZIA Gogate, 1934

Specific diagnosis.- Ornithobilharzia:

Two immature male specimens obtained from blood already clotting. Length 9.5 mm., breadth 0.488 mm. Spines and tubercles present on body. Oral sucker 0.196 mm. in diameter. Ventral sucker pedunculated 0.472 by 0.417 mm. Intestinal ceca long, running independently for most of their lengths, joining to form a common cecum 0.52 mm. from posterior end of body. Testes approximately 70, circular, feebly developed. Cirrus pouch rudimentary, posterior to ventral sucker. Gynaecophoric canal well developed.

Female unknown.

Cercaria unknown or unrecognized.

Hosts.- Primary, birds (Dendrocygna javanica Gnelin, 1789); secondary, unknown.

Location.- Vascular system (?).

Distribution.- India. (Rangoon).

Genus MICROBILHARZIA Price, 1929

Generic diagnosis.- Schistosominae: Male longer than female. Gynaecophoric canal well developed, commencing in front of the acetabulum. Suckers present in both sexes. Digestive tract similar to that of Schistosoma. Testes 18 to 20 in number, arranged in two irregular rows in anterior half of body. Genital pore situated midway between acetabulum and the anterior testis. Female slender, almost cylindrical anteriorly, flattened posteriorly. Ovary loosely spiral, slightly pre-equatorial in position. Uterus long and containing a single egg. Vitellaria occupy about one-half of the body length. Larva unknown or unrecognized.

MICROBILHARZIA CHAPINI (Price, 1929)[12]

Synonym.- Ornithobilharzia species, Chapin, 1924.

Specific diagnosis.- Microbilharzia:

Male 3.27 to 4.25 mm. long by 626 u wide. Anterior part of body short, subcylindrical; posterior part long and with lateral edges infolded, forming a deep gynaecophoric canal which originates anteriorly a short distance in front of acetabulum and extends to posterior end of body. Cuticle lacking (apparently due to maceration) in all specimens available for study. Oral sucker subterminal, 152 u in diameter; acetabulum pedunculated, 175 u in diameter, situated 437 u caudad of oral sucker. Esophagus simple, bifurcating in front of the acetabulum; intestinal ceca sinuous and uniting posteriorly about 390 u from posterior end of body. Testes 18 to 20 in number, arranged in two irregular rows originating anteriorly about 540 u to 550 u caudad of acetabulum and extending slightly posterior to equator of body. Seminal vesicle small and situated about midway between acetabulum and anterior testis.

Female 3.7 mm. long by 100 u wide. Cuticle smooth. Oral sucker poorly developed, 30 u in diameter. Ovary slender, loosely spiral, 390 u long when measured in a straight line and disregarding total length of spiral, and slightly pre-equatorial in position. The vitellaria consist of transversely elongated follicles and extend from the distal pole of the ovary to the posterior end of the body. Uterus long and apparently containing but one egg.

Cercaria unknown or unrecognized.

Hosts.- Primary, birds (Marila affinis); secondary, unknown.

Location.- Mesenteric veins.

Distribution.- North America (U.S.A., Shadyside, Md.).

12 This trematode appears to have closer affinities with species of Austrobilharzia than with those of any other genus. There are some characters in this species which differ from A. terrigalensis, type of Austrobilharzia, to such an extent that Price proposed a new genus, Microbilharzia, for it. In proposing this genus Price realizes that the characters given in the diagnosis may be of specific rather than of generic value, but in order to include this species in Austrobilharzia or in any other genera, it would be necessary to amend the generic diagnosis more or less extensively; this is regarded as inadvisable until more material is available for study.

Subfamily BILHARZIELLINAE Price, 1929

Subfamily diagnosis.- Schistosomidae: Male and female similar in form either flattened or threadlike. Suckers present or absent. Gynaecophoric canal absent or imperfectly formed. Paired intestinal ceca short; common cecum long, with or without lateral dendritic branches. Testes numerous and situated along the course of the common cecum. Uterus short and containing a single egg.

Genus BILHARZIELLA Looss, 1899

Generic diagnosis.- Bilharziellinae: Both sexes with the posterior part of the body distinctly flattened. Female shorter than male. Intestinal ceca united posteriorly at or near equator of body; common cecum long, without lateral branches and extending in a zigzag manner to posterior end of body. Male genital opening situated on left side of body a considerable distance caudad of acetabulum. Cirrus pouch present, containing the prostate and the ejaculatory duct. Seminal vesicle long and free in the parenchyma. Testes, about 110 in number, in posterior part of body on each side of common cecum. Female genital opening immediately posterior to acetabulum. Uterus short and containing a single egg. Vitellaria situated on each side of common cecum. Egg elongated anteriorly, enlarged and provided with a small spine posteriorly.

BILHARZIELLA POLONICA (Kowalewskii, 1895) Looss, 1899

Synonyms.- Bilharzia polonica Kowalewskii, 1895; Schistosomum polonicum (Kowalewskii, 1895) Railliet, 1898; Ornithobilharzia polonica (Kowalewskii, 1895) Tanabe, 1925.

Specific diagnosis.- Bilharziella:

Male 4 mm. long by 530 u wide. Body flattened, lanceolate. Oral sucker 102 u in diameter; acetabulum 136 u in diameter and situated about 760 u caudad of oral sucker. Esophagus simple, bifurcating in front of acetabulum; intestinal ceca unite posteriorly a short distance anterior to equator of body; common cecum long, extending caudally in a zigzag manner and terminating near posterior

end of body. Testes numerous, about 110 in number, situated on both sides of the common cecum. Cirrus pouch present, containing the ejaculatory duct and a well-developed prostate. Seminal vesicle long and only partially enclosed by the cirrus pouch. Genital pore on left side of body, 800 u caudad of acetabulum.

Female about 2 mm. long and 250 u wide. Body form similar to that of male. Oral sucker 51 u in diameter; acetabulum 68 u in diameter and situated 370 u caudad of oral sucker. Digestive tract similar to that of male. Ovary weakly spiral and situated in front of cecal union. Uterus short and containing a single egg. Genital pore situated immediately caudad of acetabulum. Vitellaria composed of numerous follicles lying on each side of the common cecum.

Egg 385 u to 400 u long by 100 u wide, elongated anteriorly and widened posteriorly, and provided with a small hookline spine.

Cercaria unknown or unrecognized.

Hosts.- Primary, birds (Anas platyrhynchos(= A. boschas fera), A. platyrhynchos domestica, Querquedula querquedula (= Anas querquedula), Nettion crecca (Anas crecca), Dafila acuta (= Anas acuta), Fuligula fuligula (= Nyroca fuligula = Fuligula cristata), Ardea cinerea, Nyroca leucophthalma (= Fuligula leucophthalma), and Cygnus olor); secondary, unknown.

Location.- Abdominal blood vessels.

Distribution.- Europe (Poland and Russia), and North America (U.S. Natl. Zoological Park, Wash., D.C.).

BILHARZIELLA YOKOGAWAI Oiso, 1927

Specific diagnosis.- Bilharziella:

Male flat, 2.3 mm. long by 96 u wide; sides of body parallel, posterior extremity truncate. Gynaecophoric canal short, extending from immediately caudad of acetabulum to level of cecal union (according to Oiso's figure). Oral sucker subterminal; acetabulum situated about 300 u caudad of oral sucker. Esophagus about 250 u long; intestinal ceca unite about 500 u from anterior end of body; common cecum sinuous and terminating about 75 u from posterior extremity of body. Testes oval, 50 to 70 in number, situated on each side of the common cecum; seminal vesicle large and irregular in outline, and situated between the cecal branches.

Female very slender, 3.4 to 4 mm. long by 65 u wide. Egg spindle shaped, 226 u long by 62 u wide, and containing a well-developed miracidium.

Cercaria furcocercous, pharyngeal (?), spinose. Body cylindrical in shape, 262 u long by 64 u wide; tail stem 363 u long by 39 u wide; furcla rami 258 u long by 19 u wide. Eyespots present, situated about 100 u from anterior end of body. Acetabulum comparatively large and well developed, and situated 235 u from anterior end of body. Pharynx present (?). Penetration glands consist of three pairs of large cells, the ducts of which open at anterior edge of oral sucker and are capped by an equal number of piercing spines. Germ cells lie in median line caudad of acetabulum. Excretory system pattern consists of seven pairs of flame cells in body and one pair in tail stem.

Hots.- Primary, birds (duck, presumably Anas platyrhynchos domestica); secondary, snail (Lymnaea radix).

Location.- Portal and intestinal veins.

Distribution.- Formosa.

Genus DENDRITOBILHARZIA Skrjabin and Zakharow, 1920[13]

Generic diagnosis.- Bilharziellinae: Body of both sexes elongated. Cuticle without spines or tubercles. Suckers absent. Digestive system similar to that of Bilharziella; common cecum long, zigzag, and provided with short, club-shaped or branched, lateral ceca. Genital pore of male in anterior part of body and to left of median line. Testes numerous, situated on each side of common cecum and extending from the cecal union to the posterior end of the body. Vitelline follicles numerous, situated along the course of the common cecum.

DENDRITOBILHARZIA PULVERULENTA (Braun, 1901) Skrjabin, 1924

Synonyms.- Bilharziella pulverulenta Braun, 1901; Dendritobilharzia odhneri Skrjabin and Zakharow, 1920.

[13] This genus has many characters in common with Bilharziella, but the absence of suckers and the branched condition of the common cecum as characters warrant the recognition of Dendritobilharzia as a valid genus.

Specific diagnosis.- Dendritobilharzia:

Male 8 to 8.3 mm. long by 1 to 1.5 mm. wide. Cuticle without spines or tubercles. Suckers absent. Esophagus 690 u long; intestinal ceca united posteriorly about 920 u from the esophageal bifurcation; common cecum long and zigzag, and provided with short club-shaped, sometimes branched, lateral ceca. Testes about 110 in number, situated along the common cecum for its entire length. Seminal vesicle long, spiral, and situated in the anterior sixth of the body. The genital pore is located on the left side about 1.35 mm. from the anterior end of the body.

Female (according to Semenov, 1927) 1.5657 mm. long by 0.2875 mm. wide. Body divided into two parts by an irregular transverse groove, the anterior portion being 0.4228 mm. long and the posterior portion 1.1427 mm. long. Suckers absent. Oral aperture terminal. Esophagus slightly wavy; common cecum zigzag and extending to posterior end of body. Ovary 0.1026 mm. long by 0.0914 mm. wide, situated immediately caudad of transverse groove and to one side of median line. Vitelline follicles numerous and distributed throughout posterior part of body.

Cercaria unknown or unrecognized.

Hosts.- Primary, birds (Querquedula querquedula (=Anas querquedula) and Anas platyrhynchos (= A. boschas); secondary, unknown.

Location.- Blood vessels.

Distribution.- Africa (Dongola, Sudan), and Europe (Russia).

DENDRITOBILHARZIA LOOSSI Skrjabin, 1924[14]

Specific diagnosis.- Dendritobilharzia:

Male unknown.

Female 14.2 mm. long by 1.41 mm. wide. Oral sucker and acetabulum absent. Esophagus 450 u long; intestinal ceca united posteriorly about 3.47 mm. from the esophageal bifurcation; common cecum as in D. pulverulenta. Genital organs, consisting of a spiral, tubular ovary, and an unpaired vitelline duct, lie in the space between the intestinal ceca. The vitellaria consist of follicles

[14] This description was based by Skrjabin (1924) upon a single female specimen. In discussing this species, he regards it as unlikely that this form could be identical with D. pulverulenta because of the great difference in size.

situated along the course of the common cecum.

Cercaria unknown or unrecognized.

Hosts.- Primary, birds (Peleancus onocrotalus); secondary, unknown.

Location.- Blood vessels

Distribution.- Europe (Russia).

Genus TRICHOBILHARZIA Skrjabin and Zakharow, 1920

Generic diagnosis.- Bilharziellinae: Body slender and divided into two portions; the anterior wider portion separated from the posterior threadlike portion by a single dilation. Oral sucker smaller than acetabulum. Gynaecophoric canal absent. Cirrus pouch and seminal vesicle present. Testes numerous and situated in posterior portion of body. Female unknown.

TRICHOBILHARZIA KOSSAREWI Skrjabin & Zakharow, 1920

Specific diagnosis.- Trichobilharzia:

Male 4 mm. long; anterior portion of body 60 u wide, posterior portion 20 u wide; between the anterior and posterior portions the body is dilated to 150 u in width and this part is covered with fine spines. Oral sucker 30 u in diameter; acetabulum 50 u in diameter, spiny and situated 690 u caudad of oral sucker. Testes numerous, 50 u long by 18 u wide, and situated in the posterior threadlike portion of the body. Cirrus pouch 200 u long. Seminal vesicle 220 u long. Genital pore 1.26 mm. from anterior end of body.

Female unknown.

Cercaria unknown or unrecognized.

Hosts.- Primary, birds (Querquedula querquedula = Anas circia); secondary, unknown.

Location.- Blood vessels.

Distribution.- Europe (Russia).

Genus GIGANTOBILHARZIA Odhner, 1910

Generic diagnosis.- Bilharziellinae: Female cylindrical and shorter than the somewhat flattened male. Posterior extremity of both sexes provided with lateral lobelike projections. Cuticle without spines or tubercles.

Suckers absent. Gynaecophoric canal reduced to a short groove, situated in anterior part of body. Digestive system similar to that of Bilharziella. Testes originate caudad of gynaecophoric canal and extend to posterior end of body. Cirrus pouch absent. Genital pore situated at anterior end of gynaecophoric canal and slightly to the left of the median line. Ovary moderately long and spiral. Vitelline follicles occupy about nine-tenths of body length. Uterus short and containing a single egg.

GIGANTOBILHARZIA ACOTYLEA Odhner, 1910

Specific diagnosis.- Gigantobilharzia:

Male 140 to 165 mm. long by 250 u to 350 u wide in expanded specimens; when preserved, the length is about one-half that of the expanded specimens, the width being 450 u to 650 u and the thickness about three-fourths of the width. Anterior end of the body either pointed or blunt, depending upon amount of contraction during fixation; posterior end provided with peculiar lobelike projections which give it the appearance of being obliquely truncate. Suckers absent. The gynaecophoric canal is reduced to a groove-like depression, 550 u to 750 u long by 100 u wide in flattened specimens, and situated 500 u from anterior end of body. Oral opening terminal; esophagus 180 u long; intestinal ceca short and united posteriorly at anterior end of gynaecophoric canal; common cecum long and terminating near posterior end of body. Testes consist of numerous follicles situated along the course of the common cecum. Terminal portion of the genital system (Endapparat) consists of a cirrus pouch containing the ejaculatory duct, prostate and a portion of the seminal vesicle, and is situated on a small papilla at the anterior end of the gynaecophoric canal and slightly to the left of the median line.

Female 30 to 35 mm. in length, slender, circular on cross section, and 100 u to 120 u in diameter. Anterior end of body attenuated; posterior end is similar to that of male. Esophagus 700 u to 900 u long; intestinal ceca unite posteriorly about 2 to 3 mm. from anterior end of body; common cecum slender and extending to posterior extremity of body. Ovary tubelike and spiral, situated anterior to cecal union. The oviduct arises from the posterior pole of the ovary and passes to a large seminal receptacle, and then extends forward ventrally to the ovary and unites with the vitelline duct a short distance

in front of the ovary. Vitellaria unpaired, composed of rounded follicles, extending from the cecal union to the posterior end of the body. Uterus short and containing but one egg. Genital pore median, about 60 u from the anterior extremity.

Egg oval, about 100 u long.

Cercaria unknown or unrecognized.

Hosts.- Primary, birds (Larus fuscus, Hydrocoloeus melancocephalus, and H. ridibundus); secondary, unknown.

Location.- Intestinal veins.

Distribution.- Europe (England and Sweden).

GIGANTOBILHARZIA MONOCOTYLEA Szidat, 1930

Specific diagnosis.- Gigantobilharzia: The diagnosis of the male is mainly taken from sections of the parasite, as only immature forms were found in whole. Is much smaller and slenderer than G. acotylea. Possesses an oral sucker which is lacking in G. acotylea. The area which contains the testicular bladder and the cirrus pouch is much greater than in G. acotylea. The oral sucker shows a well-progressed involution; diameter .02 by .025 mm. A large fragment of the anterior end 7 mm. long by .09 mm. wide at the anterior end and .15 mm. wide further back was found. Esophagus 3 mm. long. Gynaecophoric canal unrecognized. The testicular follicles considerably behind the juncture of the ceca. Semen bladder longer than in G. acotylea. Genital pore shortly before the union of the ceca in the corner formed by their meeting. Cuticle unarmed.

There were no complete females found. A fragment of the front end 7 mm. long, and a fragment from the middle portion of the body 15 mm. long were discovered. Oral sucker lacking. The anterior end gradually tapers to form a blunt end. Numerous vitelline follicles much smaller than those of G. acotyles, lying on both sides of the ceca and filling up the body to the posterior end. 20-30 eggs in the uterus which are elliptical in outline and measure .13 by .1 mm. Contain a complete miracidia which does not deviate from those of other blood trematodes. The female has a broadened posterior end.

Cercaria unknown or unrecognized.

Hosts.- Primary, marsh birds (Laurs ridibundus, Podiceps cristatus, and Anas boschas); secondary, unknown.

Location.- Mesenteric veins.

Distribution.- Baltic Sea (Memal River, Curische Nehrung).

PART IV

DISCUSSION OF THE PHYLOGENETIC RELATIONSHIPS OF THE BLOOD-INHABITING TREMATODES

In any discussion concerning the evolution of a small group within a larger one it is necessary to take into consideration the main stem from which the larger group has been derived. This is particularly true in a phylogenetic study of the blood flukes. They, of course, are one sub-group of a larger group of parasitic flatworms. The theories concerning the evolution of the blood flukes follow those for the evolution of parasitic forms generally. The oldest theory, which has been completely discarded, is that parasites arise spontaneously from non-living matter or from living matter in a diseased condition. This old so-called "spontaneous generation" theory has been completely invalidated by the experiments of such scientists as Tyndall and Pasteur. Another theory, which is no longer seriously entertained, is that free-living animals introduced into the body of a plant or animal become suddenly parasitic. This theory has been replaced by the now generally accepted one that there is a slow evolution from the free-living forms to the truly parasitic. Free-living individuals frequently pass into

a symbiotic stage, that is, a state consisting of a mutually beneficial intimate relationship between individuals otherwise free-living, one furnishing the other with oxygen and deriving benefits from it in the form of food. The green algae Chlorella, which live within the tissues of Hydra, are a good example of this relationship. From the symbiotic stage there is a gradual change to the commensal stage, in which one animal furnishes room for another, but receives nothing in return. Examples of this relationship are pilot fish for sharks, and the small fish living among the tentacles of the portugese-man-of-war. The next stage is that of ectoparasitism, in which, at first, occurs the temporary ectoparasite (e. g. feather lice of birds), and then the more or less permanent ectoparasite (e. g. ring worm) where the relationship may be injurious to the host. From this stage develops the inaximum state in parasitic evolution, the endoparasitic form. In the endoparasitic forms occur great variations within single groups. This fact can be attributed to a variety of causes; for example, the length of time that the species has been with a specific host, where it is located, its specificity, etc. Of prime importance to this fact is the evolutionary pathway the parasite has taken to its final site of infection. The first requirement of the parasite

is food, and since we find that the least modified parasites are those which are found in the intestinal contents of the hosts, having first infested the mouth and the alimentary tract, this ~~them~~ is one of the first evolutionary sites of infection of endoparasites. In the presence of such an abundance of food various modifications are brought about, such as a reduction in the organs of locomotion and, even more striking, a reduction in the organs of alimentation. (i. e. in the tapeworms the digestive tract has entirely disappeared, except in very early larval stages). The next site of infection would be one closely allied to the intestines and the hepatic portal system which takes the digested and semi-digested frood from the intestine and in turn supplies energy in the form of food and oxygen to the intestines. In the presence of such a medium the parasite undergoes more modifications of the alimentary tract, and? modifications of the integument, since its food can be directly absorbed. From the hepatic portal system the parasites may find sites in the muscles, the liver, and other extensions of the circulatory system where they would supplied with an abundance of food by the venous system as well as having an outlet for their eggs into the blood stream and thus into the excretory system of their hosts. Since the schistosomes are para-

sites of the blood stream and are primarily found in the hepatic portal system and mesenteric veins, where there is an abundance of digested food, we can expect to find many modifications of the alimentary tract, such as the loss of the suckers, the loss of the pharynx, the loss of the acetabulum, etc. These factors are of importance in demonstrating the monophylogenetic relationship of the blood flukes, where the condition of distomate, monostomate, and non-stomate forms exists. Stunkard (1921) demonstrated Footnote for reference that the adhesive organs were independently modifiable, thus indicating a monophylogenetic relationship of the blood flukes as far as the adhesive organs are concerned.

There is much evidence supporting the gradual change theory. The most important, of course, ~~being~~ derived from application of the biogenetic law (ontogeny recapitulates phylogeny): All parasites pass through stages like free-living forms. For example, young stages in the life cycle of parasites have organs of locomotion which may be lost upon entering the host, or upon reaching the adult stage, and organs of sense present in these early stages are often lost in the mature parasites.

In the group of blood flukes it has been demonstrated that the miracidia of the various forms are similar to each other and differ markedly from those of other trematodes.

Cort (1919 and 1928) and Monticelli (1893), (quoted by Stunkard, (1921)), compared the miracidia of Hapalotrema, Spirorchis, and Schistosoma and found that there was essential agreement among them. It has also been demonstrated that the cercariae are similar and, as far as has been shown, of the fork-tailed type. Faust (1919) in discussing the group Furcocercariae recognized "a complete series of larval forms from those with a pharyngeal sphincter to the human schistosome cercariae." Since this paper deals primarily with the phylogenetic arrangement of the Super-family Schistosomatoidea, and since it has been amply demonstrated that there is essential agreement among the larval forms of the blood flukes, the writer feels that the above data are adequate for this thesis. Since, as has been demonstrated, there is essential agreement among the larval forms of the blood flukes, and since the biogenetic law has been demonstrated as being thoroughly reliable, it is logical to conclude that a very close relationship exists between the blood flukes. However, in the absence of descriptions of many of the larval blood flukes, caution should be used in accepting any sweeping generalizations.

The change from a fortuitous free-living existence to one in which protection from enemies and a good supply of

food are guaranteed, has brought about profound modifications in the helminth parasite: A reduction in the organs of locomotion; a reduction in the organs of alimentation, and a specialization in their outer integumentary covering; the development of means of attachment (e. g. acetabula and hooks); and many others. As the parasite reaches the peak of its development, these modifications become increasingly diverse, depending upon various circumstances such as the specificity of the parasites toward their hosts and their site of location within the host. This is an important point which plays a large part in the explanation of the great modifications among blood flukes.

It is a significant fact that the most degenerate blood flukes, the suckerless forms with reduced alimentary tracts, are found in the oldest and most primitive vertebrates, the fishes, and that the most specialized forms, the dioecious forms, are present in the most recent and highly specialized forms, the birds and mammals. This correlation of the evolution of parasites with the evolution of their hosts is very suggestive of an ancient origin of the blood flukes. While the time of their entry into the vascular system cannot be determined with anything like certainty from the evidence at hand, it seems probable that they have long been parasitic in vertebrates. Either

they were parasitic in vertebrates before the division of the vertebrate stem into its present classes and have remained with their hosts through the transition periods and the evolution of the modern classes of vertebrates, or they have changed their primary hosts from one class of vertebrates to another as these developed, a power of adaptation that seems very unlikely.

It would be in accordance with the first theory to assume that the evolution would have been from the Aporocotilidae, in the simplest hosts, through the Spirorchides, in the more complex hosts, to the Schistosomatidae, in the highest hosts, birds and man. Another fact which adds significance to this belief is that in the endoparasitic forms we have various degrees of host-parasite-specificity, and that the greater the specificity of a parasite toward its host, the greater are its modifications or variations from the specific group or genus to which it belongs. In other words, it adapts itself to an existence which is the same, since its host or hosts are the same. Thus, again, the evolution would be from the standard forms to the modified forms: Aporocotilidae through Spirorchidae to Schistosomatidae. To further elucidate this concept, the following statement can be made: as a parasite gains in host-parasite-specifi-

city, it ~~becomes~~ is modified to become better fitted for its existence in or upon its host or hosts. Of course, this host-parasite-specificity would appear in the forms in the lower vertebrates as well; but since they had already adapted themselves to their environment, it is a plausible inference that where the same type of parasite appears in higher vertebrates, it will display a greater degree of modification or specialization due to the greater complexity of this more specialized group of hosts and the adaptations of the parasites to this greater complexity.

An important consideration from this viewpoint is the dioecious condition which exists among the Schistosomatoidea. Since they are found in the most complex vertebrates and display great specificity as to host, it is natural to assume that they are the most specialized among the blood flukes, and this assumption may be verified by morphological comparisons.

According to the observations of Cort (1921, 1926) and Tanabe and Yokagawa (1923), sex among schistosomes is determined at fertilization, and all individuals produced by parthenogenetic multiplication from a given miracidium are of the same sex. According to Lindner (1914), there are two different kinds of spermatozoa produced in Schistosoma, and he contended that this heterozygous condition

of the male is responsible for the sexual differentiation of these diecious trematodes. The maturation processes in hermaphroditic forms are not well known; the observations reported are insufficient and far from conclusive, but from the work of Goldschmidt on Polystoma integerrimum, Dicrocoelium lanceolatum, and Zoogonus mirus, of von Dingler on D. lanceolatum, of A. and K. E. Schreiner on Gregoire, of Cable on Cryptocytle lingua, of Wasserman on Z. mirus, of Schellenberg on Fasciola hepatica, and of von Kemnitz on Brachycoelium salamandrae, it appears that the spermatazoa as well as the eggs are all alike, and that every zygote contains complete sets of factors for the production of both male and female gametes. The work on Schistosoma indicates that the males are heretogametic; and, if these observations are correct, the problem narrows to an explanation of this change in maturation.

Considerable light is thrown on the problem by a study of aphids, rotifers, and the smaller crustacea, where sexual reproduction nromally alternates with a series of parthenogenetically produced generations and corresponding differences occure in maturation phenomena. It is true that in these species the female is heterozygous for sex, producing two kinds of eggs, but here experimental alteration of the sex ratio has shown the effect of environmental factors in

determining the kinds of eggs produced. In these forms environmental conditions seem to be the determining factors that control the type of gametogenesis and the sex of the ensuing individual. In daphnids, Smith (1912) has shown that the type of egg and therefore the type of maturation can be influenced by temperature and food. In the series of papers Whitney (1914, 1916) and others, have discovered that the rotifers, if fed on small amounts of the colorless flagellate, Polytoma, continue to produce parthenogenetic females, but when fed abudantly on chlorophyll containing forms, Euglena, etc., that produce oxygen, male-producing females appeared and sexual reproduction occurred. A most interesting and significant observation, and one that may bear directly on the origin of the dieicious condition of blood flukes, was made by Shull and Ladoff (1916) when they demonstrated that the production of males in rotifers is correlated with the supply of oxygen. The direct effect of oxygen was later questioned by Whitney (1919), but it appears certain, however, that these investigators have succeeded in influencing the type of maturation by modification of environmental condition. By influencing maturation in aphids, Morgan (1909) and von Baehr (1909) have made important observations on the determination of sex. Similar results were reported by Malsen (1906) for

Dinophilius. Here it seems that the type of maturation is controlled by the size and organization of the egg. In experiments on moths, Seiler has shown that the relative numbers of the two kinds of eggs produced can be influenced by temperature changes at critical stages in the process of maturation.

If the character of the gametes is determined at maturation, and if maturation changes are subject to environmental influences, we have a probable explanation for the origin of the diecious condition in the blood flukes. The schistosomes are the only diecious trematodes known, and they are found only in the veins of homothermal vertebrates; consequently, the environmental factors that could have caused the change may be investigated. If, on the advent of vertebrates with a four-chambered heart, complete separation of arterial and venous circulation, and a mechanism for maintaining a constant high temperature, the blood flukes for some reason came to occupy the portal and mesenteric veins, they would be located in a medium differing distinctly from that of their relatives living in the arteries of the cold-blooded vertebrates. In this new environmental complex undoubtedly occurs the factors responsible for the diecious condition. In the portal and mesenteric veins of birds and mammals are found the ma-

jority of the hermaphroditic forms. A possible reason as to their greater abundance in the veins rather than in the arteries, as in the lower animals, would be that in the homothermal vertebrates the oxygen content is too high in the arteries and that a lower amount, ~~maybe~~ perhaps the same as in the lower vertebrates, would be found in the veins. Another reason may be that the portal and mesenteric veins are richer in food and that it is one of the older sites for parasitical life. Another environmental factor that may play a part is the increased rate of metabolism in the homothermal forms.

A corresponding development of the diecious condition occurs in other forms of animal life, ~~and~~ but we are as yet unable to satisfactorily explain the phenomenum. There is one class of the Platyhelminthes, the Nemertia, consisting almost entirely of free-living forms, ~~where~~ in which the diecious condition also is found. It is in line with the reasoning so far brought out in this paper to conclude that since the development of a diecious condition is observed in the most complex stages of the free-living forms, this condition would also correspondingly arise in the most specialized types of parasitic forms.

There are other great morphological differences occurring in the blood flukes which must be explained before a

specific relationship can be shown. In this category will be found a great variation in the size of the uterus in the different species. This can be partially explained by the fact that the flukes' existence in the blood vessels and the constant pressure exerted on the fluke by the elasticity ~~of these vessels' walls~~ the walls of these vessels would tend to produce a narrow elongated body and prevent the development of a spacious uterus. This constant pressure, varying in intensity with the pulsations of the heart, would prevent the accumulation of eggs in the body of the parasite and actually force them out of the uterus. Since the eggs are voided in the blood vessels and must pass through the tissues of the host to the outside world, a process of long duration, they must be provided with hard shells and contain large amounts of food for the embryo during the period of migration. This requires the production of large eggs, and the increased size of the egg would be a potent factor in hastening its discharge from the uterus. Consequently the uterus has been shortened and in some cases is so short the egg is discharged as soon as it is formed.

In some of the blood flukes Laurer's canal is absent. This structure is generally regarded as vestigeal by students of the Trematoda; It is absent in the Monopisthoco-

tylea and certain families of the Digenia, while in others it is represented by a blind sac opening from the oötype. Its absence in the most degenerate and most highly specialized blood flukes is therefore not surprising.

Among the blood flukes is noted a migration of the genital pore to the dorsal side. A corresponding dorsal migration of the genital pore is found in Axine, Microcotyle, and Octobothrium, and its relations were traced by Stunkard (1915). This dorsal migration is not, therefore, of significance in the evolution of Schistosomes, since corresponding migrations are found among other groups of Trematodes.

In a consideration of the genera belonging to the families Spirorchidae and Aporocotilidae, this writer has been influenced considerably by the published accounts of both martail and larval characters. He was impressed at once by the scarcity of references to the developmental stages of the members of the family group, but where references to larval characters were made, these were drawn on heavily as evidence in support of the systematic arrangement of the groups as a unit.

The members of the family Spirorchidae offer considerable material for the study of the phylogenetic relationship that exists among the genera and species.

Odhner (1912) placed the genus Hapalotrema Looss, (1899), the only known genus of turtle blood flukes at that time, in the subfamily Liolopinae of the family Harmostomidae, from which family the author derived the schistosomes. Ward (1921) removed the genus Hapalotrema from the subfamily Liolopinae, claiming such a classification to be totally unnatural, and placed the genus Hapalotrema with the genus Spirorchis, and these, with his newly created genus Proparorchis, in a new family, Proparorchiidae. Stunkard (1923) suppressed the genus Proparorchis as a synonym of the genus Spirorchis and proposed the family Spirorchidae to replace the family Proparorchiidae. He presented much evidence in support of the origin of the Spirorchidae from the suckerless Aporocotilidae through the genus Spirorchis, showing rather conclusively that the fundamental body plans of both the Spirorchis and Aporocotyle are essentially identical. Mehra (1934), following Odhner's conclusion, derived the Spirorchidae from the Harmostomidae through the subfamily Liolopinae, and placed the family Aporocotilidae close to the family Spirorchidae, after using the genus Hapalorhynchus as the key genus connecting the blood flukes with the family Harmostomidae. From Hapalorhynchus Mehra derived the genera Vasotrema, Hapalotrema, and the family Schistosomatidae. From the stem of Hapalorhynchus giving rise to Hapalotrema, we find Mehra deriving the families Spirorchidae, Aporocotilidae, and Sanguinicolidae.

This paper is in agreement with Stunkard (1923)[15] in considering the Spirorchidae as being descendents of the more primative Aporocotilidae through the genus Aporocotyle to the genus Spirorchis for the following reasons:

1. Spirorchis and Aporocotyle agree in the position of the excretory pore and the general features of the excretory system.
2. Spirorchis and Aporocotyle are alike in the absence of an acetabulum and the delicacy of the musculature.
3. Both have prominent ventro-lateral nerves.
4. The digestive systems correspond in the absence of a pharynx and the presence of esophageal glands.
5. There is a close similarity in the relative length of the ceca and the position of the bifurcation of the digestive tract.
6. The reproductive systems are strikingly similar:
   a. The testes are situated in the intercecal area anterior to the ovary, and, although in Aporocotyle they consist of irregularly massed follicles, they are arranged in a double linear series.
   b. In both Spirorchis and Aporocotyle the terminal part of the vas deferens is enclosed in a small and poorly developed cirrus sac and the cirrus is eversible.
   c. In Aporocotyle the genital pore is dorsal, at the left of the median line near the posterior end of the body, and, although it is anterior to the ovary in Aporocotyle, it is behind the ovary in Sanguinicola. In Spirorchis the genital pore is sinistral on the ventral side of the body, but this disagreement is not important since in the description of Hapalorhynchus the migration of the genital pore from a ventral to a dorsal position has been explained.
   d. In both genera the ovary is oval, situated on the right side of the body a short distance caudal to the testes.
   e. The relations of the oviduct, vitelline duct, and uterus are very similar, although in Aporocotyle, as in Schistosoma, the uterus is longer and Laurer's canal is absent. This latter structure is regarded

[15] H. B. Stundard, "Studies on North American Blood flukes," American Museum of Natural History. Bulletin, XLVIII, 165-221 (July, 1923).

as vestigeal, and its absence in Aporocotyle is not subversive to the thesis.

f. The vitellaria in both genera are similarly situated, enveloping the ceca throughout most of their length, although they extend further posteriad in Spirorchis. The single vitelline duct is explained by Odhner by the reduction of the duct of the left side.

In the excretory, nervous, muscular, digestive and reproductive systems of Aporocotyle and Spirorchis, there is substantial agreement, and, although there are dissimilarities, the long series of structural likenesses constitutes more than a fortuitous and convergent adaptation. One is then justified in regarding these forms as closely related, and the blood fluke series may be regarded as proceeding from Sanguinicola and Aporocotyle through Spirorchis to Hapalotrema and also to the schistosomes.

Odhner in 1911, while discussing the relationships of Aporocotyle with Sanguinicola, pointed out that the H-shaped gut of the latter is derived by a great reduction in the length of that of the former. He also mentioned that the condition of the alimentary system in Deontacylix shows an intermediate position between that of Aporocotyle and Sanguinicola. It seems obvious from the account of the morphology of the genera and species of the genera and species of the family Aporocotilidae that there is a descending series in the evolution of the alimentary system of the four suckerless genera of blood flukes, Aporocotyle-Paradeontacylix-Deontacylix-Sanguinicola. In all these genera the gut is of the basic

H-shaped type. In Aporocotyle the esophagus is of about the same length as in the Spirorchidae and Schistosomadie; it is also surrounded, as in these families, by the salivary gland cells. The intestinal ceca are also of the same length and end near the posterior end. From the gut of Aporocotyle can be derived that of Paradeontacylix, in which the esophagus is long and opens in the center of the H-shaped intestine. The anterior ceca are small, i.e., about one-third as long as the esophagus, but the posterior ceca are much smaller than those of Aporocotyle, terminating much in front of the posterior end. From Aporocotyle onwards there is a great tendancy in this series of genera towards a reduction in length of the intestinal ceca, and from Paradeontacylix onwards there is also a tendancy towards a greater development of the anterior horns. This culminates in the extremely small H-shaped gut of Sanguinicola, in which both the anterior and the posterior horns are of nearly equal size. Deontacylix, in this respect, occupies an intermediate position between Paradeontacylix and Sanguinicola. It has posterior ceca much smaller and anterior ceca much larger than those of Paradeontacylix, but they are both of nearly equal size, as in Sanguinicola, although much larger than in the latter genus.

There is a close similarity in the genital organs of these four genera. The testes of all of them tend to be

divided into a follicular condition, although in Aporocotyle and Paradeontacylix they are irregularly aligned in a condition approximating that of the Spirorchidae. In Aporocotyle the testes, large in number, occupy irregularly the entire intracecal space region between the ovary and the intestinal bifurcation; in the Spirorchidae they occupy the same position with this difference, that their number is smaller and they are arranged in a linear series. The writer, as has been already brought out, believes that Aporocotyle represents the origin of the Spirorchidae. In Deontacylix and Sanguinicola the testes are diffuse organs, occupying entirely the available space between the intestinal bifurcation and the ovary, although in Sanguinicola, however, their arrangement is somewhat regular in a double row, but this is obviously a departure from the irregular arrangement of the Aporocotyle type along another direction from that shown by the testes of Spirorchidae. The shape of the ovary varies in different genera or even in different species of the same genus and should not be considered of much importance from the point of view of these relationships. It is spherical or ovoid in Aporocotyle, shield-shaped in Paradeontacylix, slightly lobed in Deontacylix, and H-shped in Sanguinicola. It is of interest to note, though, that the ovary of Paradeontacylix possesses slightly lobed margins, the ovary of Deontacylix

is slightly lobed, and the ovary of Sanguinicola is distinctly lobed, having an H-shaped appearance.

The cirrus sac in Aporocotyle is fairly well developed; it is smaller in Paradeontacylix and Deontacylix, although it is conical and bent as in the former. The uterus in Aporocotyle and Paradeontacylix is convoluted and contains a number of ova. In Deontacylix it is much larger and filled with numerous ova. As in the Schistosomidae the genus Schistosoma has secondarily developed a uterus containing a large number of ova, whereas its ancestors have a very small uterus containing only one ovum, in the same way Aporocotyle, Paradeontacylix, and Deontacylix have secondarily acquired a large uterus filled with numerous ova from their ancestral form. In this respect Sanguinicola, with a very small uterus containing a single ovum, shows the primitive condition.

In the excretory, nervous, a muscular systems also there is substantial agreement not only among these four genera but also between them and the Spirorchidae. In the scheme of the relationships of the blood-fluke families Aporocotilidae and Spirorchidae, it appears certain, as shown in Figure 1, that Aporocotyle represents the ancestral form which are evolved along one line its closely related genera Paradeontacylix, Deontacylix, and Sanguinicola and along another the genus Spirorchis of the family Spirorchidae.

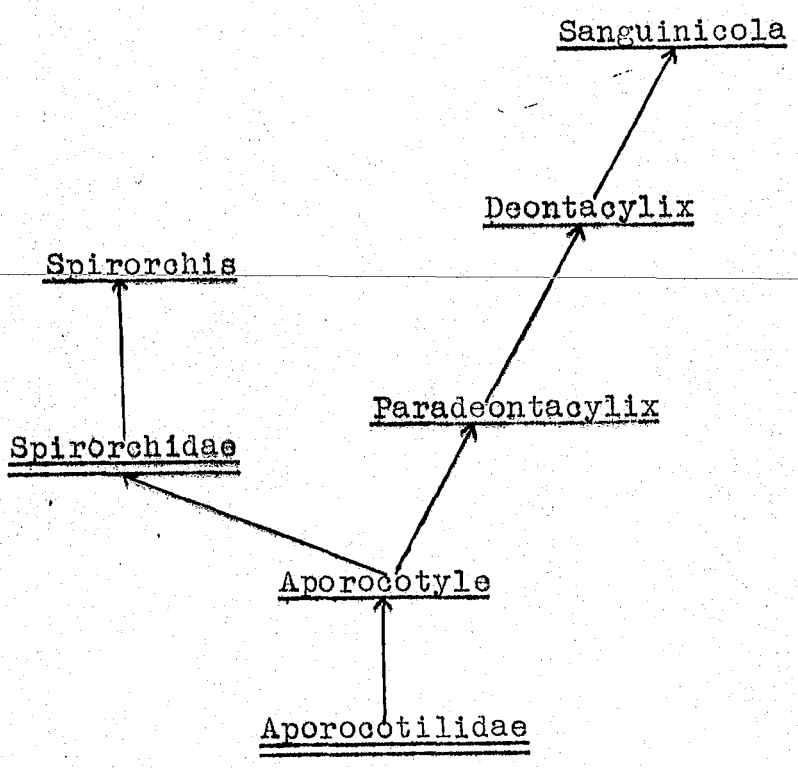

Figure 1. A schematic diagram of the probable relationship among the various genera of the Aporocotilidae , with an indication of the relationship these genera bear to the Spirorchidae.

The writer is in the mainpart in agreement with Byrd (1939), who presents a schematic diagram of the probable phylogenetic relationship among the various genera of the Spirorchidae, with an indication of the relationship these genera bear to other blood flukes. He outlines his reasons for this relationship as follows:

". . . . Within the family Spirorchidae we derive the genus Spirorchis from the Aporocotyle through a reduction of the uterus, the linear arrangment of the testes, and a loss of the forward directed blind pouches of the ceca.. The acquisition of the suckers, expecially the ventral sucker, is explained perhaps in the condition described for such a form as Spirorchis orientalis (Mehra), whereas the shifting of the testicular follicles to a position posterior to the ovary is evidenced by the nature of these follicles as they are found in Spirorchis blandingi MacCallum and S. olandingioides n. sp.. Such forms as these give rise to Hapalotrema polesianum (Ejsmont) and the typical Hapalotrema. Carrying this migration further we find the testes becoming more and more reduced as they migrate so that along one line the single testis lies posterior to the ovary as in the genus Vasotrema, and along a second line where two testes remain, one placed anterior and the other posterior to the ovary, as in the genera Hapalorhynchus and Amphiorchis. The genera Unicaecum, Neospirorchis, and Learedius we derive directly from the genus Spirorchis. The family Schistosomidae is closely related to the Spirorchidae through the genus Neospirorchis, while the family Sanguinicolidae is more primitive and perhaps is an offshoot from the Aporocotyle stock giving rise to the Spirorchidae."[16]

The writer disagrees in part with the schematic diagram presented by Byrd[17] in that he is of the opinion that the Schistosomidae are derived from the genus Learedius, for

[16]Elon E. Byrd, "Studies on the blood flukes of the family Spirorchidae. Part II. Revision of the family and description of new species," Tennessee Academy of Science. Journal, XIV, 143-144 (Jan., 1939).

[17]Ibid., 145.

reasons developed later, and that the genus Neospirorchis is an offshoot from the genus Spirorchis and not from the genus Unicaecum, as is represented by him in his diagrammatic relationship. To further elucidate this, there is only a common cecum present in Unicaecum, and yet the contention built up by the diagram is that from a condition of the bifurcation of the ceca develops one in which there is only one ceca, which, in turn, develops into the original condition in the genus Neospirorchis. This same type of development also supposedly occurs with the esophagus and with the seminal receptacle. Laurer's canal is lost in the genera Unicaecum and Neospirorchis and is found among some of the schistosomes of the sub-family Bilharziellinae and also in the genus Ornithobilharzia of the sub-family Schistosominae. For these reasons the writer concludes that the diagram of Byrd is erroneous and that it should be represented as in figure 2.

The present review of the family Schistosomadae involves the taxonomy of a rather large group of blood flukes which has been extensively surveyed by many investigators. It concerns, therefore, not a problem of the rearrangement and nomenclature of the family but one of the probable phylogenetic relationships of the various genera. In the consideration of this type careful attention should be given to the larval stages, but it is almost impossible to do so in this case because of the scarcity of references to the developmental

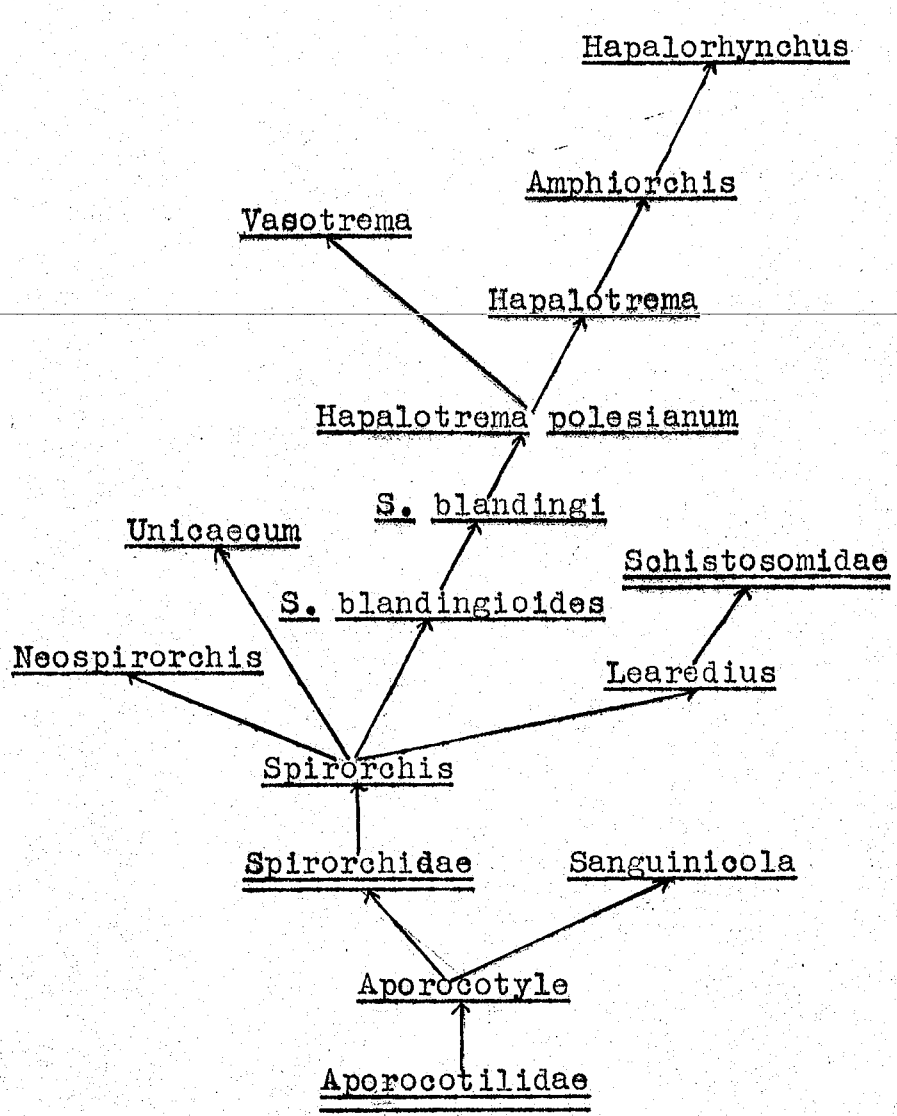

Figure 2. A schematic diagram of the probable phylogenetic relationship among the various genera of the Spirorchidae, with an indication of the relationship these genera bear to the other blood flukes.

stages. Out of eleven genera there are only three in which larval characters have been described. This consideration, therefore, of a probable phylogenetic relationship, depends almost entirely upon martail characters.

It has been previously brought out in this paper that there is essential agreement between the families of blood flukes in the super-family Schistosomatoidea; ~~so~~ from this fact the problem becomes one of tracing the evolution of the various genera. Since the probable phylogenetic relationships of the family Spirorchidae have already been successfully demonstrated by Stunkard (1921) and Byrd (1939), the problem narrows to the tracing of the phylogenetic relationships of the family Schistosomadae. It is, therefore, first necessary to show that there is a close agreement between the families Spirorchidae and Schistosomadae. The writer considers that the schistosomes are descended from the spirorchids for the following reasons:

1. The Schistosomadae and the Spirorchidae agree in the general features of the excretory system and in the position of the excretory pore.
2. They are alike in that the musculature is delicate and that although in some schistomsomes the acetabulum is present, it is lacking in those forms which most closely resemble the Spirorchidae.
3. Most of the schistosomes possess both oral and ventral suckers, but among the Bilharziellinae they are either absent or the oral sucker alone is present. This condition closely approximates that of the Spirorchidae. The conclusion is held by most students of trematodes that the monostomate flukes are descendents of distomate ancestors. It becomes evident that the loss of the

ventral sucker as the individual matures, ~~as~~ which has been demonstrated by Mehra (1934) in his description of the genus Plasmiorchis Mehra (1934), indicates this structure to be a relic of the past or a structure in the process of development. This does not in any way settle the question of the origin of the distomate character, which is, of course, outside of the scope of the present paper.

4. The digestive systems of both correspond in the absence of a pharynx and the presence of esophageal glands.
5. They differ in that in the shistosomes the common cecum is short and in the Spirorchidae it is long, although the position of the bifurcation of the tract compares closely. This fact can partly be explained by the development of the diecious condition in the schistosomes, thus allowing for greater expansion of the digestive ceca.
6. The reproductive systems are as closely related as could be possible where one group has the diecious condition. The location of the various organs is similar:
   a. The testes of Spirorchidae are situated in the intercecal area and are primarily follicular in character. The testes of the shistosomes are separated, although in the genus Gigantobilharzia they are follicular in character, and are located in the intercecal area. The development of the condition of separate testes can be traced from the follicular condition in Gigantobilharzia to the condition of a series of testes in the higher forms of the shiatosomes.
   b. The seminal vesicle is either free or partly enclosed in a weakly developed cirrus pouch in the Spirorchidae. The same condition occurs in the schistosomes with a gradual loss of the cirrus pouch in the most modified forms.
   c. In the Spirorchidae, as has already been indicated, there is a migration of the genital pore to the ventral side. In the schistosomes there is essential agreement in the genital pore being located on the ventral side with a gradual migration to the anterior portion of the gynaecophoric canal.
   d. In the Spirorchidae the ovary varies from an oval condition to a spiral, tubular condition. Among the schistosomes this spiral condition exists among the Bilharziellinae with a gradual loss of the spiral condition and the ovary becomes an elongated tube among the most highly modified forms of the Schistosomidae.
   e. The relations of the oviduct, vitelline duct, and uterus are very similar, although in most

schistosomes, Laurer's canal is absent. This latter structure, as has already been stated, is regarded as vestigeal by students of the trematodes. The uterus in most schistosomes is much longer but among the Bilharziellinae, it closely approximates in size that of most Spirorchidae and there is also found a long uterus among the genera Neospirorchis, Amphiorchis, and Learedius, of the family Spirorchinae. The uterus of the Spirorchidae usually only contains but one egg and this condition also exists among the Bilharziellenae and some Schistosominae.

f. The vitellaria of Spirorchidae are extensive, situated primarily in the intercecal area, and are vollicular in character. The vitellaria of schistosomes agree essentially with the above data with minor variations among the most specialized forms.

g. The eggs are similar being ovoid, although among the shistosomes there are some forms which possess spines and among the Spirorchinae there are some forms which possess polar prolongations.

7. Wherever it was possible to examine descriptions of the larval forms it was found that there is essential agreement as has been demonstrated by Faust (1919).

It is the opinion of the writer that the change to a diecious condition constitutes the starting point for the evolution of the schistosomes. Working from this basis, and in the absence of sufficient descriptions of larval forms, the martail form which most closely approximates the genus Learedius is the genus Trichobilharzia. Both have verrucae on their cuticula; both have oral suckers; both have long cirrus pouches; the acetabulum is present in both; there is not development of a gynaecophoric canal in Trichobilharzia; both have numerous separate testes situated in the posterior intercecal area; both have long seminal vesicles, although in Learedius it is partly enclosed in the cirrus pouch; and

have long esophagi with surrounding gland cells. From the genus Trichobilharzia, along one line of development, the genus Gigantobilharzia is here derived through the development of a small gynaecophoric canal located at the anterior part of the body, the loss of the oral sucker, the loss of the acetabulum, the development of a simple esophagus; and the development of numerous follicular testes located caudally. From Gigantobilharzia the writer derives the genus Dendritobilharzia through the further development of the gynaecophoric canal, the absence of the oral sucker, the absence of the acetabulum, the development of dendritic branches from the ceca, the loss of the follicular appearance of the testes, and a spiral ovary developed from the slightly spiral tubelike ovary of Gigantobilharzia. Along another line of development, is derived from Trichobilharzia the genus Bilharziella through the development of a short, imperfect gynaecophoric canal, the retention of the oral sucker, the retention of the acetabulum, the development of a simple esophagus, the further development of numerous testes in the posterior intercecal area, and the further development of the seminal vesicle.

The genus Heterobilharzia of the sub-family Schistosominae closely resembles the genus Bilharziella in the great number of testes and their position in the posterior part of the

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and their irregularity of placement, also in the absence of diverticula or anastomases? from the ceca as well as in other features of the digestive apparatus, and also in the presence of a cirrus which encloses a prostate and part of the seminal vesicle, a characteristic common in the family Bilharziellinae. Therefore the writer derives the genus Heterobilharzia from the genus Bilharziella. From the genus Heterobilharzia, along one line of development, is derived the genus Austrobilharzia through the loss of the oral sucker in the female, the development of anastomases from the ceca, the movement of the testes to the intercecal area, although they retain their irregular distribution, and the presence of the prostate and part of the seminal vesicle in the cirrus pouch. There are some corresponding developments such as these in the other genera, but they cannot be traced to Austrobilharzia nor can Austrobilharzia be derived from them, since these developments in these genera come from different lines of derivation. Another factor which tends to ~~uphold~~ support this idea is that there is no loss of the oral sucker in the females of any other genera. Directly from Heterobilharzia, is derived the genus Ornithobilharzia through the formation of anastomases from the ceca, the retention of a great many testes which tend to become aligned in two distinct rows and have moved anteriorly, the loss or retention of a rudi-

mentary cirrus, the loss of the prostate, and the freeing of the seminal vesicle. Along a third line of development from Hetero-bilharzia is derived the genus Microbilharzia through the oral sucker becoming subterminal, the development of ceca which resemble those of the genera infesting mammals, the retention of a pedunculated acetabulum, the loss of some of the testes and their movement anteriorly and also their arrangement in two irregular rows, the retention of the cirrus pouch and the freeing of the seminal vesicle from its enclosed condition in the cirrus, and the location of the genital pore remaining the same. From the genus Microbilharzia is derived the genus Paraschistosomatium through their close resemblence in the morphology and location of the suckers, the ceca, the acetabulum, the esophagus, and the genital pore, and also through the loss to some extent of the spiral condition of the ovary and the retention of a long uterus which has become full of eggs in contrast to the long uterus of Microbilharzia which contains only one egg. The writer derives along one line of development, the genus Schistosomatium from the genus Paraschistosomatium through the development of lateral diverticula from the ceca, and the change from a spirally curved ovary to an oval one; in other characteristics they remain essentially the same. Along the other line of develop-

ment I derive the genus Schistosoma through their close resemblence in the anatomy of the suckers, the ceca, the acetabulum, and the uterus, and also through the retention of a long ovary which has become straightened out and in the great development of the uterus.

Figure 3 represents the writer's idea of the probable interrelationship existing between the various genera of the family Schistosomidae and the family Spirorchidae.

This diagrammatic relationship supports a view which was previously presented: The blood flukes were parasitic in vertebrates before the division of the vertebrate stem into its present classes and have remained with their hosts during the transition periods and the evolution of the modern classes of vertebrates. This can readily be seen by examining the hosts of each genera. From the reptilian host, the turtle, of the genus Learedius there develops in avian hosts the genera of the family Bilharziellinae which in turn gives rise to the family Schistosominae which also contains forms which have avian hosts. From the avian host of the genus Microbilharzia there develops in mammalian hosts the three genera: Paraschistosomatium, Schistosomatium, and Schistosoma. Along the line of the developments just given there arise various branches from the main line of these branches giving rise to two of the most diversified blood

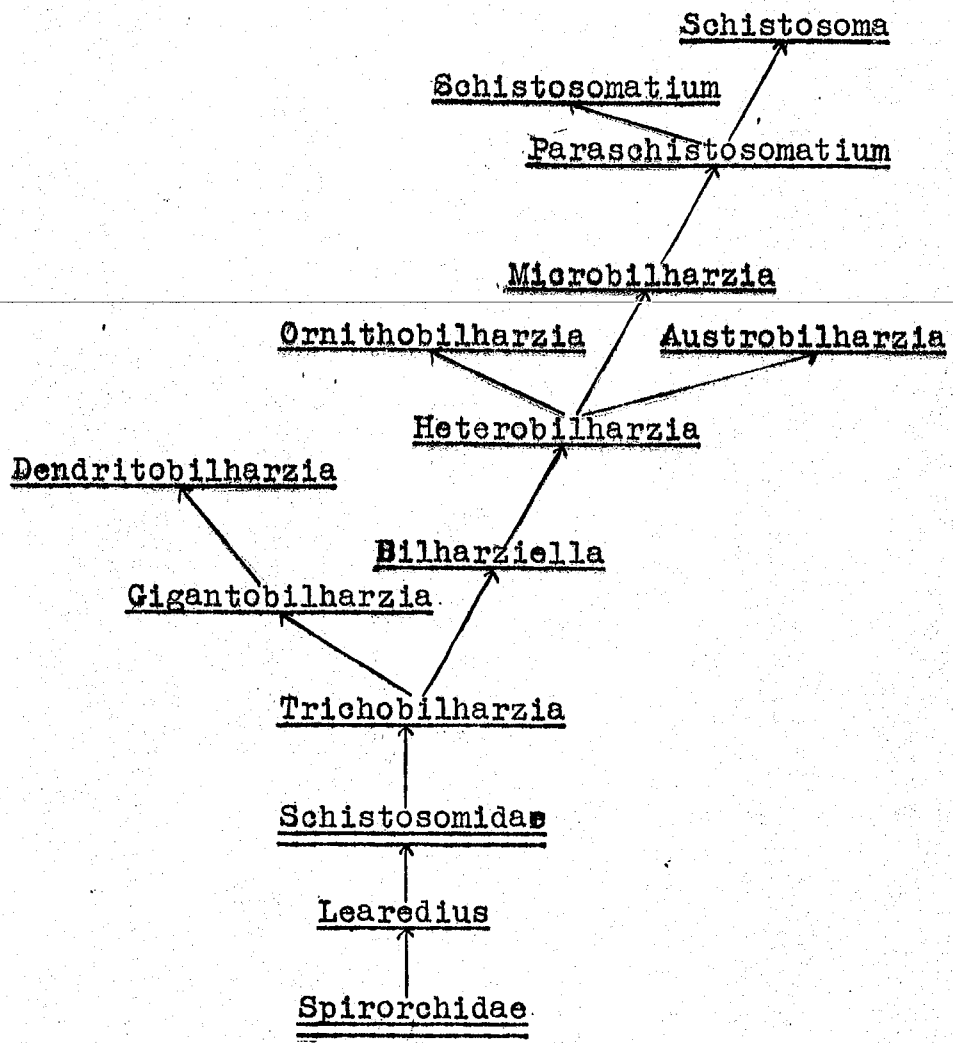

Figure 3. A schematic diagram of the probable phylogenetic relationship among the various genera of the Schistosomidae, with an indication of the relationship these genera bear to the other blood flukes.

flukes found in birds, Austrobilharzia and Ornithobilharzia, and one giving rise to the most modified form found in mammals, Schistosoma. It is interesting to note, at this point, that there is a gradual loss of the number of the testes, a gradual migration of them anteriorly, alignment of them in two rows, and a gradual migration of the genital pore to the anterior end of the gynaecophoric canal as this phylogenetic relationship is traced upward, and where there are branches to the side from the main line of development, corresponding changes occur.

PART V

RESUME & CONCLUSIONS

1. The super-family Schistosomatoidea has been reviewed in the light of many recent observations made upon the families, genera, and the species assigned to the group.

2. ~~An investigation of~~ The genetic and evolutionary relationships of the blood-inhabiting trematodes ~~has~~ have been ~~made with discussions being made of~~ investigated, and the various problems brought up through such an investigation have been discussed.

3. The relationship existing between the genera of the family Aporocotilidae is discussed, and a probably phylogentic tree is constructed to show this relationship. Figure I page 133.

4. The relationship existing between the various genera of the family Spirorchidae is discussed, and a probably phylogenetic tree, adopted mainly from one set up by Byrd (1939), is constructed to show this relationship. Figure II, page 136.

5. The relationship existing between the various genera of the family Schistosoma is discussed, and a probably phylogenetic tree is constructed to show this relationship. Figure III, page 144

should this be "probable" see next page,

hypothetical or theoretical or presumptive?

6. The relationship existing between the various families of the blood flukes is discussed, and a probable phylogenetic tree is constructed to show this interrelationship. Figure IV, page 148

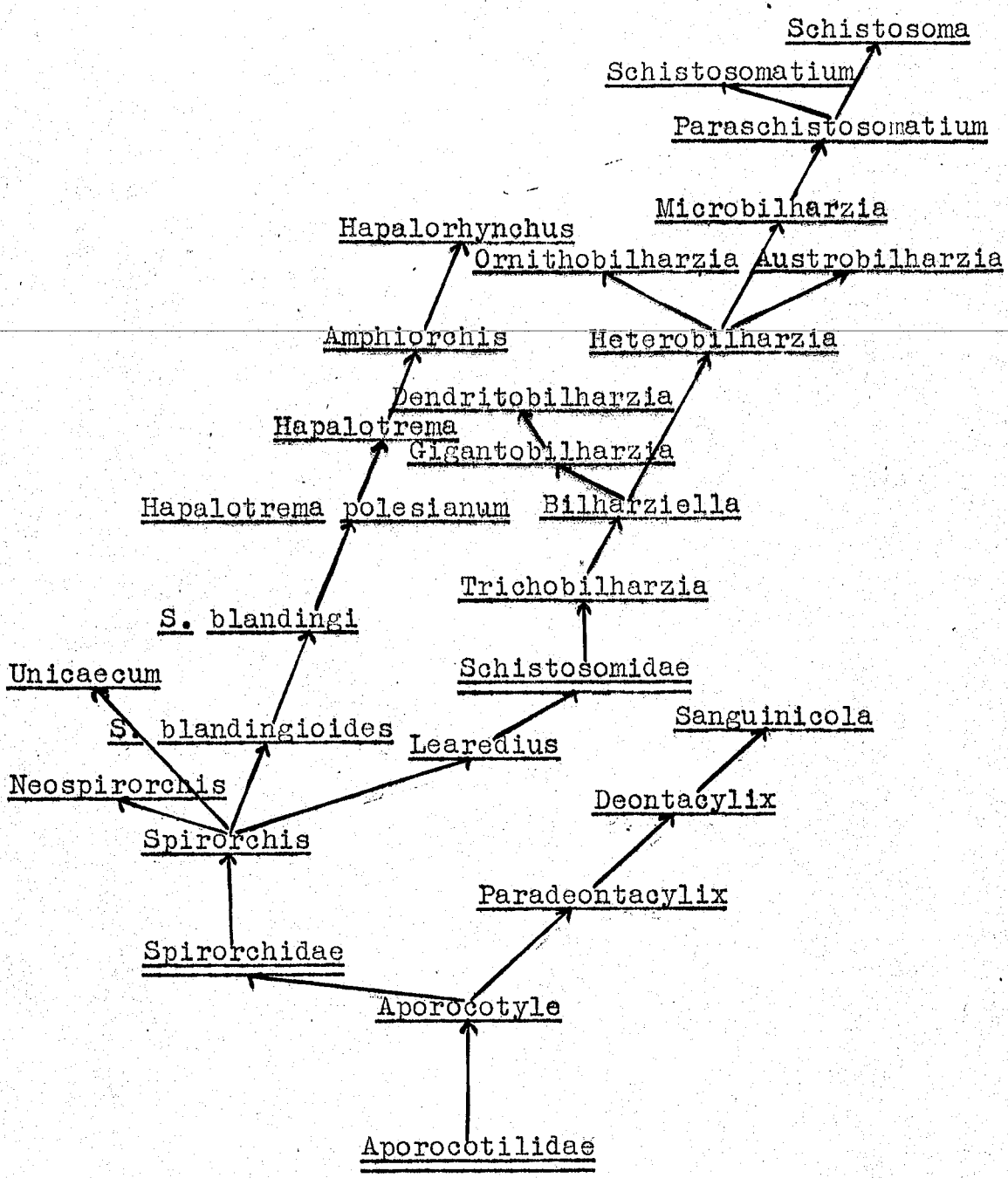

Figure 4. A schematic diagram of the probable phylogenetic relationship of the families and genera of the superfamily Schistosomatoidea.

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APPENDIX

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Figure 1. Sanguinicola intermedia after Ejsmont, 1926.

2. Sanguinicola armata after Plehn, 1905.

3. Sanguinicola chalmersi after McIntosh, 1934.

4. Aporocotyle simplex after Odhner, 1910

5. Paradeontacylix odhneri after Layman, 1930.

6. Deontacylix ovalis after Linton, 1910.

Plate II

Figure 7. Hapalotrema loossi after Leared, 1862.

8. Hapalotrema synorchis after Luhman, 1935.

9. Spirorchis innominata after Ward, 1921.

10. Spirorchis artericola after Ward, 1921.

11. Spirorchis haematobium after Stunkard, 1922.

12 & 13. Spirorchis elegans after Stunkard, 1923.

14. Spirorchis scripta after Stunkard, 1923.

15. Spirorchis picta after Stunkard, 1923.

Plate III

Figure16. Spirorchis parvum after Stunkard, 1923.

17. Spirorchis blandingi after MacCallum, 1926.

18. Spirorchis orientalis after Mehra, 1934.

19. Spirorchis hardellii after Mehra, 1934.

20. Spirorchis sanguina after Sinha, 1934.

Figure 21. Spirorchis blandingiodides after Byrd, 1939.

22. Spirorchis pseudemyae after Byrd, 1939.

23. Spirorchis minutum after Byrd, 1939.

24. Spirorchis magnitestis after Byrd, 1939.

Plate IV

Figure 25. Hapalorhynchus gracilis after Stunkard, 1922.

26. Hapalorhynchus lyssemus after Mehra, 1933.

27. Hapalorhynchus indicus after Thapar, 1933.

28. Hapalorhynchus stunkardi after Byrd, 1939.

29. Hapalorhynchus reelfooti after Byrd, 1939.

30. Hapalorhynchus evaginatus after Byrd, 1939.

31. Unicaecum ruszkowskii after Stunkard, 1925.

32. Unicaecum dissimilis after Byrd, 1939.

Plate V

Figure 33. Vasotrema amydae after Stunkard, 1926.

34. Vasotrema attenuatum after Stunkard, 1928.

35. Vasotrema robustum after Stunkard, 1928.

36. Neospirorchis schistosomatoides after Price, 1934.

37. Amphiorchis amphiorchis after Price, 1934.

38. Learedius learedi after Price, 1934.

39. Learedius similis after Price, 1934.

Plate VI

Figure 40. Schistosoma haematobium, male, after Manson-Bahr and Fairley, 1920.

Figure 41. Schistosoma haematobium, female, after Manson-Bahr and Fairley, 1920.

42. Schistosoma japonicum, male and female, after E. W. Price, 1929.

43. Schistosoma mansoni, male, after Manson-Bahr and Fairley, 1920.

44. Schistosoma mansoni, female, after Manson-Bahr and Hairley, 1920.

45. Schistosoma indicum, male and female, after E. W. Price, 1929.

Plate VII

Figure 46. Schistosoma bovis, male and female, after Khalil, 1924.

47. Schistosoma curassoni, male, after Brumpt, 1931.

48. Schistosoma rodhaini, male and female, after Brumpt, 1931.

49. Schistosoma spindalis, male and female, after Vryburg, 1907.

50. Schistosoma spindalis, female, after Vryburg, 1907.

51. Schistosomatium pathlocopticum, male, female, egg, and cercaria, after Tanabe, 1923.

52. Plate VIII

Figure 52. Schistosomatium douthitti, male, after H. F. Price, 1931.

53. Schistosomatium douthitti, female, after H. F. Price, 1931.

54. Paraschistosomatium anhingae, female, after E. W. Price, 1929.

55. Heterobilharzia americana, male, after E. W.

Price, 1929.

Figure 56. Austrobilharzia terrigalensis, male and female, after Johnston, 1917.

57. Ornithobilharzia intermedia, male and female, after Odhner, 1910.

58. Ornithobilharzia canaliculata, male and female, after Braun, 1902.

59. Ornithobilharzia kowalewskii, male, after Parona and Ariola, 1896.

Plate IX

Figure 60. Ornithobilharzia turkestanicum, male and female, after Skrjabin, 1913.

61. Ornithobilharzia odhneri, male and female, after Faust, 1924.

62. Ornithobilharzia bomfordi, male and female, after Montgomery, 1906.

63. Microbilharzia chapini, male and female, after E. W. Price, 1929.

64. Gigantobilharzia acotylea, male, after Odhner, 1910.

65. Gigantobilharzia acotylea, female, after Odhner, 1910.

66. Bilharziella polonica, male and female, after Kowalewski, 1895.

67. Dendritocilharzia pulverentulata; a. male, after Braun, 1902; b. male, after Shrjabin and Zakharow, 1920

68. Gigantobilharzia monocotylea, anterior end of the male, after Szidat, 1930.

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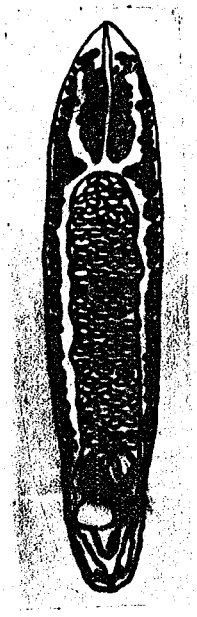

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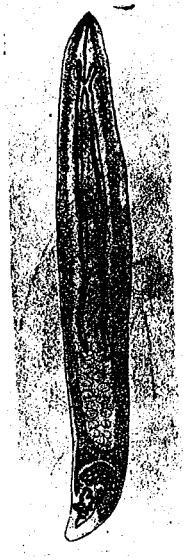

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PLATE I

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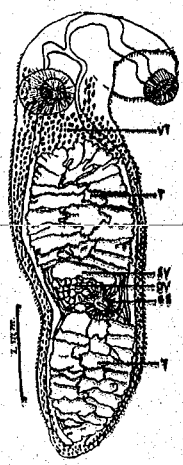

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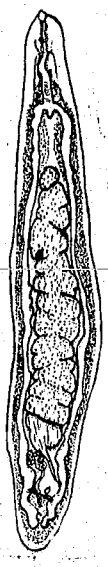

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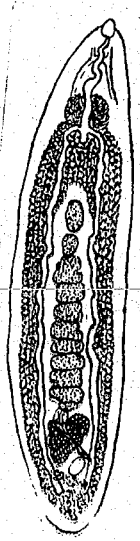

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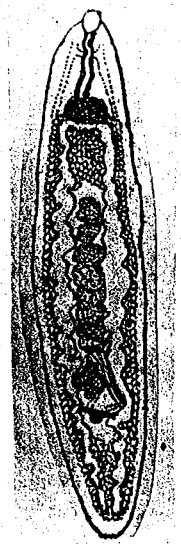

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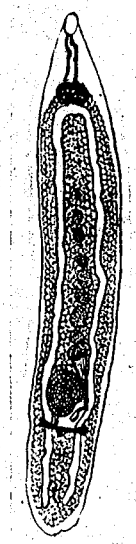

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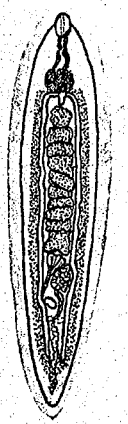

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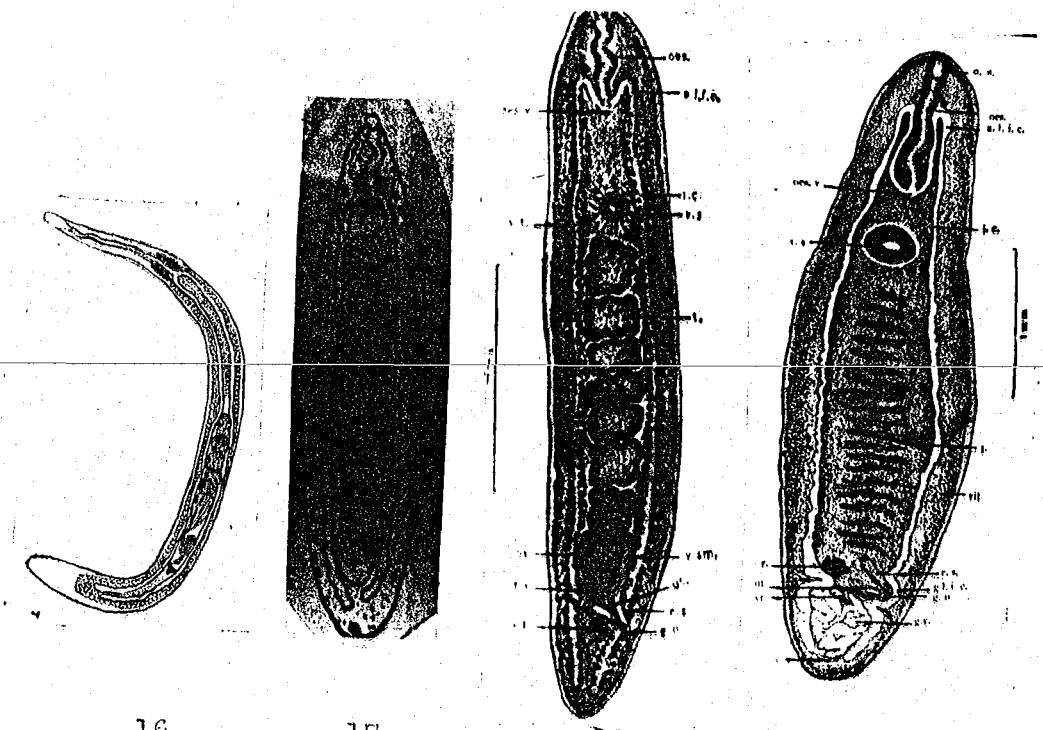

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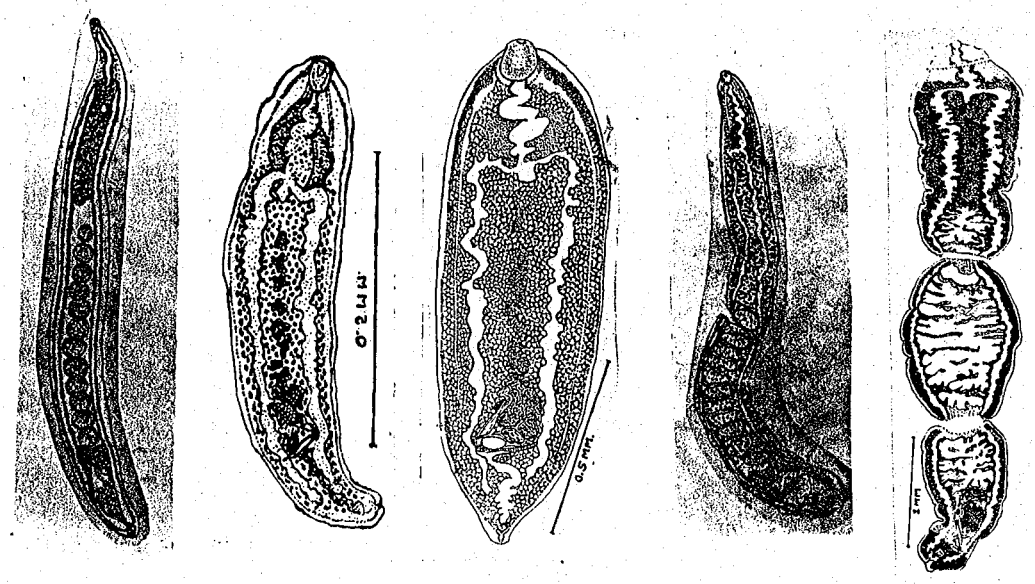

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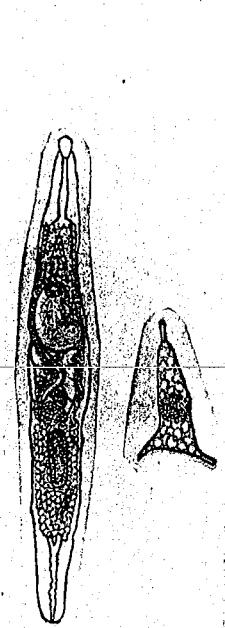

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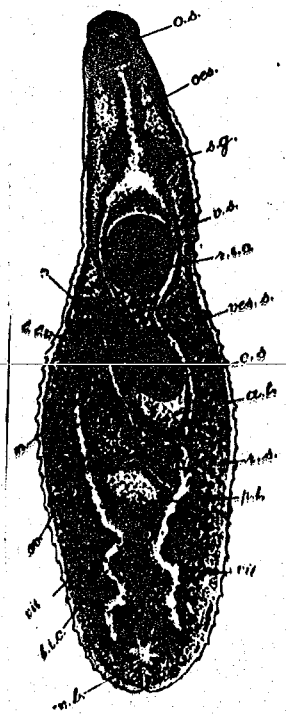

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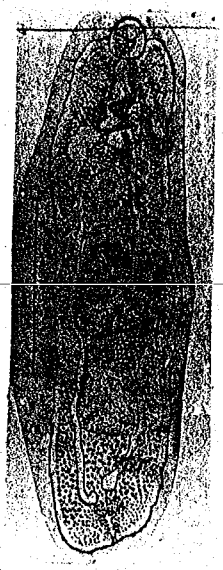

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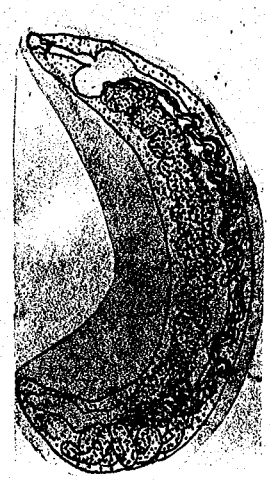

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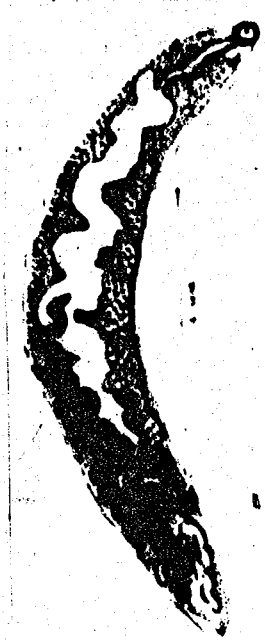

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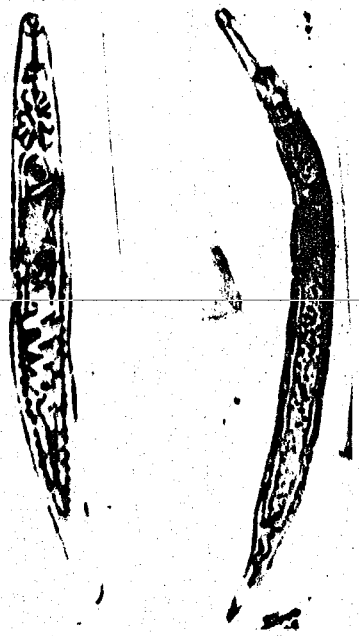

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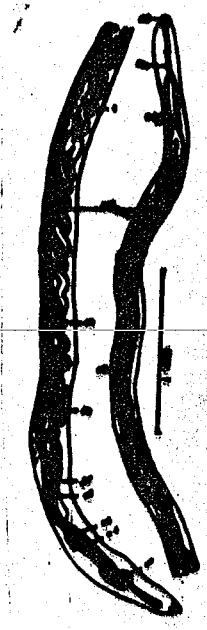

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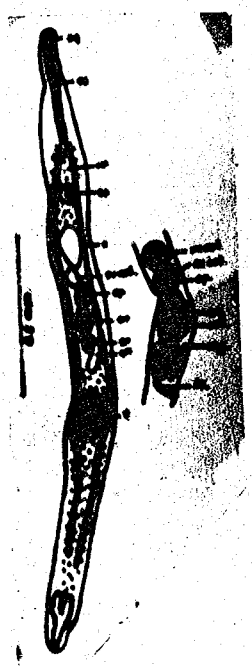

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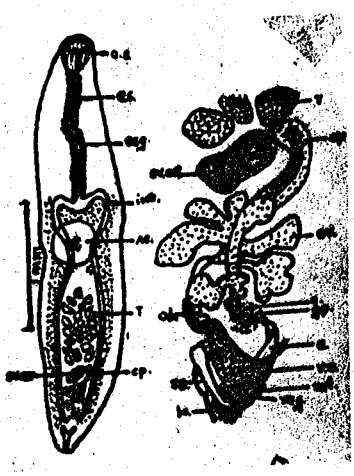

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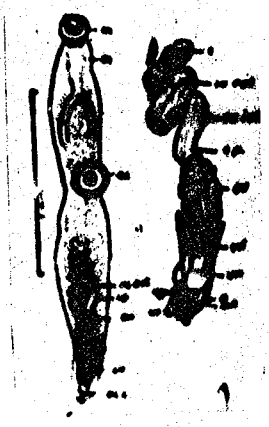

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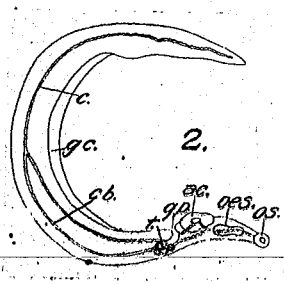
PLATE V



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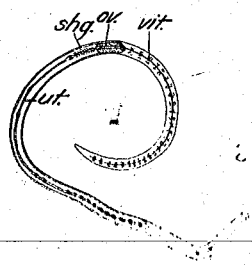

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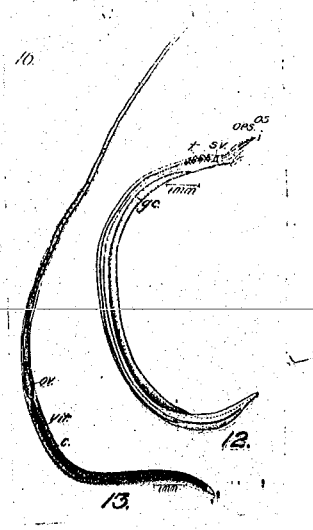

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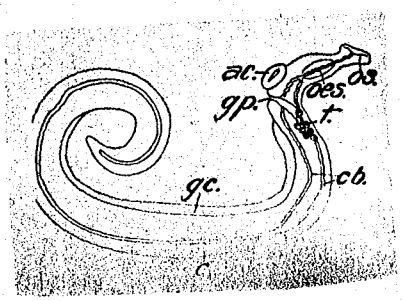

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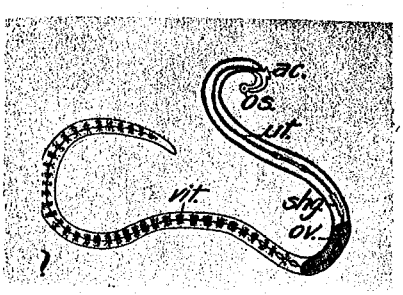

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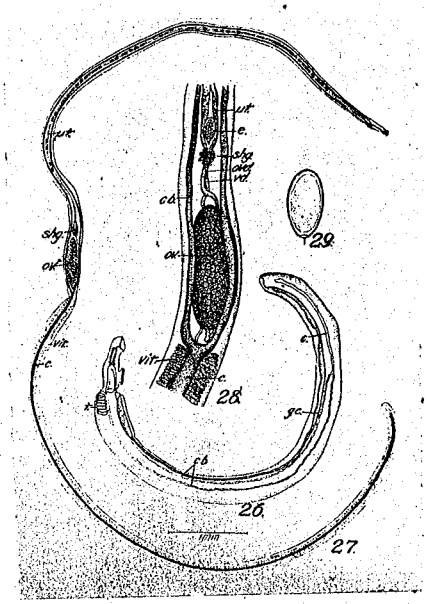

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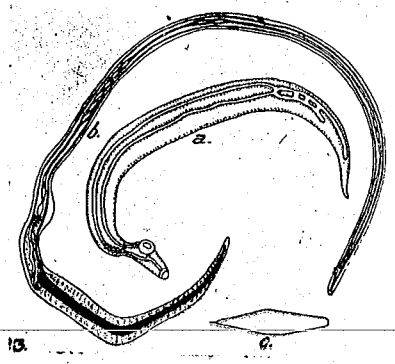

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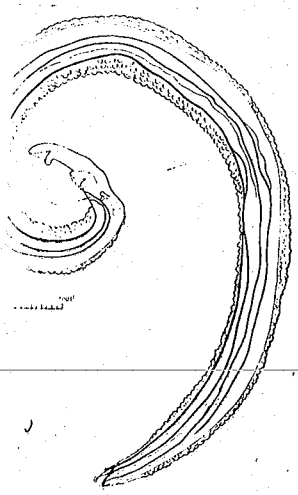

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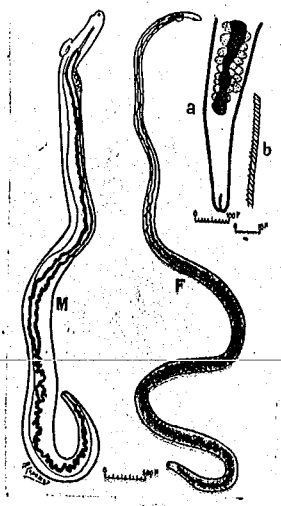

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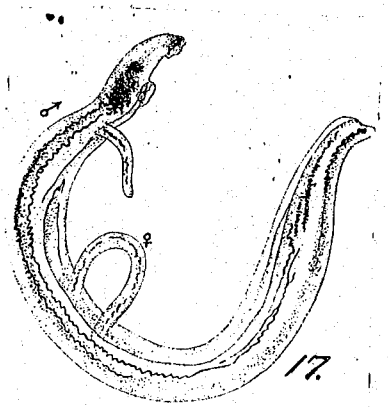

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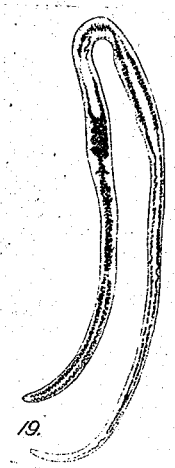

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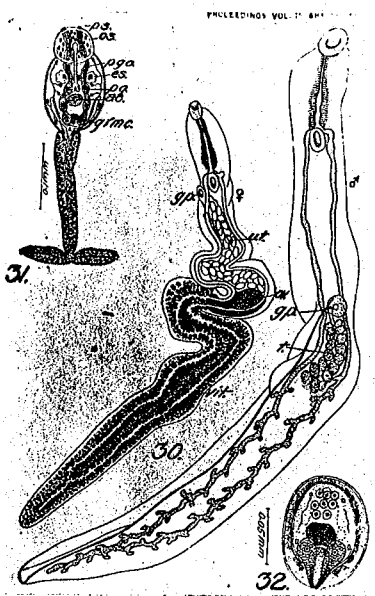

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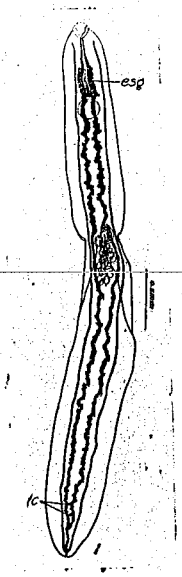

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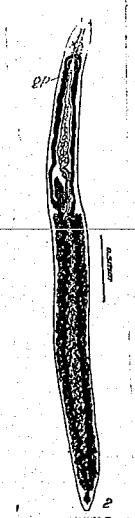

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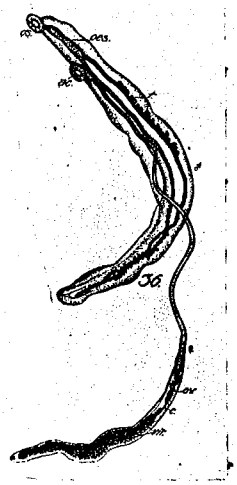

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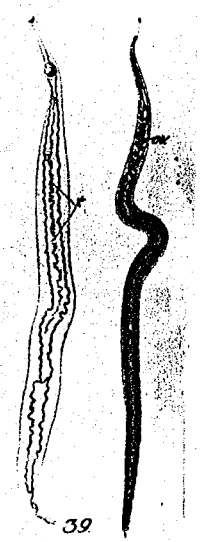

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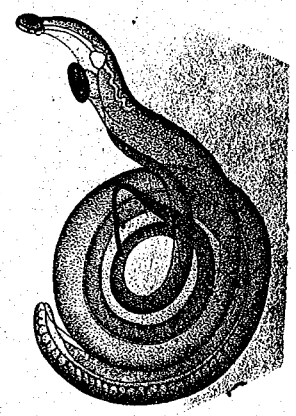

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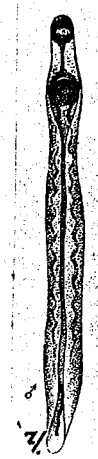

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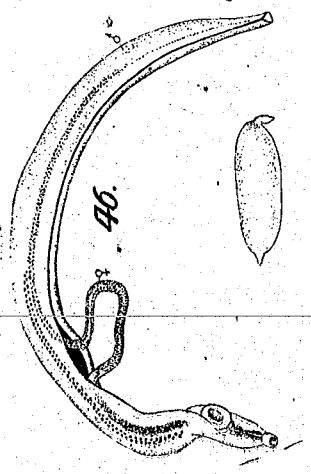

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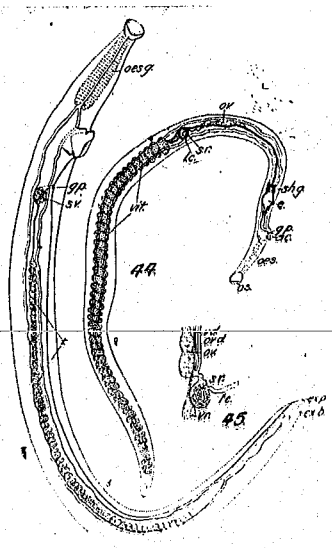

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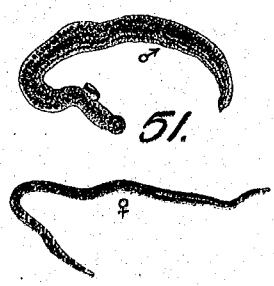

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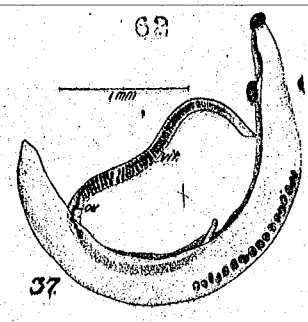

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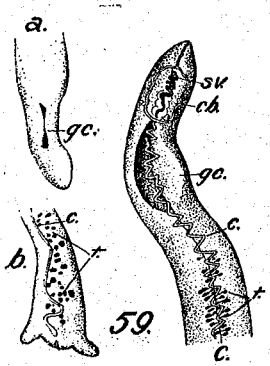

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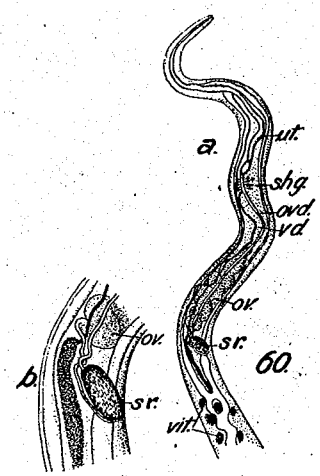

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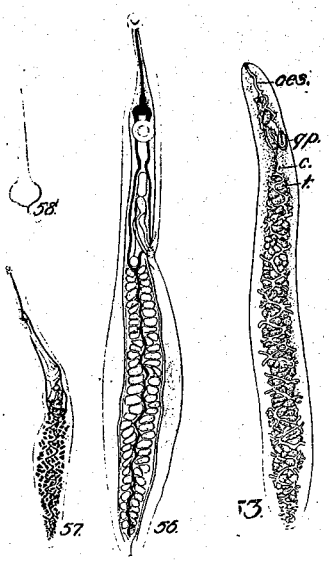

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PLATE IX